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Edited by LEON GASTER

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EDITORIAL.

A Year's Progress.

The Illuminating Engineer is now commencing its fourth year of existence, and the Illuminating Engineering Society has embarked upon its second session. When we had similar occasion to review the progress made during 1909, we mentioned the starting of the Society and its Inaugural Meeting as one of the most important events of the year.

Since then much has been done. The account of the work of the Society during its first session has already been published in detail in the report of the Council presented at the Annual Meeting on May 23rd, 1910. It will be recalled that the meetings were mainly devoted to the discussion on 'Glare' and the 'Measurement of Light and Illumination.' These discussions furnished material for widespread comment in the technical and even the daily press. For example, *The Times Engineering Supplement* published two leading articles in which the main conclusions arrived at were summarized in a readable and concise manner, and a sympathetic attitude taken towards the work of the Society. The Annual Dinner on February 10th was again of great assistance to the Society in showing the many possibilities of co-operation with other and older Institutions, and the friendly manner in which these regarded its work.

During the new session two very successful meetings have already taken place. The first meeting on November 8th, 1910, was dealt with in detail in our last number; this was devoted to the paper on 'Recent Advances in Gas Lighting' delivered by Mr. F. W. Goodenough. At the second meeting, on December 9th, Prof. E. W. Marchant has dealt in the same way with electric lighting. A very interesting discussion was the result. Readers will find a complete account of this meeting on pp. 29–49 in this number.

The Society, therefore, is now successfully carrying out its intention of

providing an impartial platform for the discussion of problems connected with lighting. The President, in his opening remarks on November 8th, mentioned that it was hoped during the present session to deal with specific practical questions in greater detail. An interesting illustration of this will be provided by the next meeting, which is to be devoted to 'Library Lighting,' on January 16th, 1911. It is particularly gratifying to note that the co-operation of the Library Association has been secured, and that special measures will be taken to ensure that the views of the architect, the librarian, and others interested, besides those of the lighting engineers will be well represented.

Spread of Interest in Illumination.

During the year the Society's influence has been steadily extending. Ideas on the subject of illumination which were regarded as novel only two years ago are now generally accepted, and the number of references to the subject in the technical press is still increasing. We should like to take this opportunity of expressing our appreciation of the services of other journals in making known our aims and objects, and doing a substantial valuable share of the work of educating the public in illuminating engineering. Readers who have studied our 'Short Notes on Illuminating Engineering' month by month will entertain no doubt on this point. When we turn to the proceedings of societies, we are again struck by the number of papers dealing with various aspects of illumination which have been presented. At the Royal Institution Prof. S. P. Thompson and Mr. W. Duddell lectured on this subject at the commencement of the present year; Mr. J. Darch dealt with the hygienic aspects of lighting at the Annual Congress of the Royal Sanitary Institute; Mr. P. J. Waldram discussed daylight illumination in a paper before the Society of Architects; Messrs. J. S. Dow and Val H. Mackinney brought the subject of surface brightness and its measurement before the notice of the Optical Society and the Physical Society of London; and the writer was privileged to deliver an address on Factory Lighting before the Association of Foreman Engineers in Charge, a lecture before the London Institution, and a paper on the Hygienic aspects of Lighting at the International Congress of Industrial Hygiene in Brussels. There have also been a series of important papers dealing with street lighting, to which further reference will be made shortly. Meanwhile the above list, incomplete as it is, may serve to show the variety of societies that now deal with the question of illumination.

Factory Lighting and Industrial Illumination.

Among special subjects which have attracted considerable amount of notice during the year, one of the most important is Factory Lighting. We have previously drawn attention in this journal to the sympathetic attitude of the Home Office in this country towards this matter, and expressed our appreciation of the important precedent established by the reference to the subject, and to the work of this journal, in H.M. Chief Inspector's Report for the past year.* Equally gratifying was the interest taken in the hygienic side of industrial lighting at the Second International "Congrès des Maladies Professionnelles." Quite a number of papers by Dr. A. Broca, Dr. F. Terrien, and Mons. F. Massarelli, and others, emphasizing the importance of good lighting, and its effects upon the eyes, were read. The Congress gave special expression to its sense of the need for good illumination in safeguarding dangerous machinery, and undertook to bear the matter in mind and collect data previous to their next meeting. An important precedent was by the Illuminating Engineering Society in appointing delegates to be present at this

* *Illum. Eng.*, July, 1910, p. 419.

Congress; this will doubtless have the effect of bringing its views into notice in influential governmental quarters.

Courses of Lectures on Illuminating Engineering.

The next point we are called upon to mention is the growing recognition of the need for better instruction in Illuminating Engineering. More attention is already being given to this subject in the colleges in this country, but several speakers in the discussions of the Society during the past session have urged the need for better facilities than exist at present. It may be noted that a course of three lectures of this kind was arranged at the East London College by Professors J. T. Morris and C. M. Smith. More recently the London County Council have been taking up the question, and it has been decided that a central Opto-Technical Institute should be founded at which such questions as photometry and the study of illumination will doubtless receive attention with other optical problems. A movement has also been on foot with a view to securing special courses of lectures at various technical centres under the control of the London County Council, and we are gratified to note that a special series of six lectures has now been arranged to be delivered by Mr. J. S. Dow at the Westminster Technical Institute early in the next year. The Principal, Mr. J. Stuart Kerr, deserves congratulation on being one of the first to organize a course on these lines.

There can be no doubt, therefore, that the recognition of the need for education in Illuminating Engineering is spreading in this country. Meantime a notable step forward has been taken in the United States in the very comprehensive post-graduate course at the Johns Hopkins University organized last October. Reference to this course has repeatedly been made in this journal.*

* *Illum. Eng.*, Lond., vol. iii., 1910, pp. 417, 447, 672, 699.

Standardization of Lamps.

Questions connected with standardization have also been considered. Several speakers in the discussion at the last meeting laid stress on the need for standardization of the dimensions of glow-lamps, which also formed the subject of a special message, published in our last number, from Mr. S. E. Doane to readers of this journal. The question of nomenclature and symbols is now receiving preliminary discussion at the hands of the American Society, which will, no doubt, in due course be of service when the attempt made to secure international agreement on this point is successful.

Conclusion.

It will be seen, therefore, that the Illuminating Engineering Society has accomplished a considerable amount of work during the year, and that progress in other quarters, which is indirectly due to its stimulating influence, is constantly being made. Our chief difficulty has been in compressing this summary of its work within reasonable limits. During the year the membership of the Society has steadily increased to over 250, many of the greatest authorities on illumination in different countries having given their support. We should like to make special reference to the recent addition to the list of Dr. Moeller, the distinguished President of the International Congrès des Maladies Professionnelles, as one of the Honorary Members of the Society, and of Prof. Lummer, Prof. J. Violle, Prof. W. Wedding, Mr. W. M. Mordey, and others as Vice-Presidents of the Society. In conclusion we desire to thank all those who have contributed to the discussions of the Society and to the Journal. A special acknowledgment is due to the many distinguished corresponding members of the Society in different parts of the world who have done so much to add to the value of these discussions. The complete absence of

friction and the harmonious working together of members of the Council has been a very gratifying feature of the proceedings. One other point deserves mention—the great privilege enjoyed by the Society in having Prof. S. P. Thompson as its President for a second year. It need only be added that the outlook for the next year is equally bright, and we anticipate that in January, 1912, there will be even greater progress to record.

A Standard Specification for Street Lighting.

Yet another subject on which there has been much discussion during the past year is street lighting. For example Mr. Haydn Harrison has just dealt with the subject in a paper before the Institution of Electrical Engineers, and Mr. J. Abady also did so in a paper delivered last June at the annual meeting of the Institution of Gas Engineers. Another very comprehensive paper, which has recently been published in abstract in these columns, was that of Mr. A. J. Sweet before the Franklin Institute. These, and many other contributions, bear witness to the complexity of the subject.

An important announcement was made by the President of the Illuminating Engineering Society at the last meeting, to the effect that it had been decided to form an impartial Committee to consider problems in street-lighting and the drafting of a model specification on street-lighting.

In the discussion of Mr. Harrison's paper before the Institution of Electrical Engineers, several speakers stated their conviction of the need for an impartial and representative Committee of this kind. Naturally the matter was one which appealed primarily to the Illuminating Engineering Society, since this body has from its inception regarded lighting problems from the impartial standpoint. There are doubtless many problems in street-lighting, the solution of which is of common interest to representatives of all systems of lighting concerned.

We have no doubt that this Committee will be able to render valuable service, but it is of course essential that it should be of a thoroughly representative character. The Council of the Society, it need hardly be said, are impressed with the importance of this condition. The Committee's functions will be mainly in the direction of collecting data and ascertaining points of agreement between the different experts concerned. In doing this it will, of course, be desirable to approach different authorities on the subject and learn their views, and in this direction the international membership of the Society should be very serviceable.

Again, while the Illuminating Engineering Society has seen fit to take the lead in this matter, and quite appropriately, we feel sure that it is fully recognized that on a question of this kind the co-operation of other bodies, especially those of older standing and experience, is very necessary. No doubt before the time comes to make definite recommendations co-operation of this nature will be secured.

For the present, therefore, the Committee will do useful preliminary work by clearing the ground and preparing the way for a more definite understanding. The model specification which it is proposed that the Committee should draw up will be in the nature of a tentative suggestion and will form a valuable basis for future action. It is suggested that the preliminary specification and a report of the labours of the Council should first be drawn up and submitted for discussion at a meeting of the Society to be held towards the end of the session. Any new points then brought up can be considered by the Committee, and such modifications inserted as strike them as desirable. This specification could then be tried for a definite length of time, so that any further improvements necessary could be finally adopted at the expiry of the trial period agreed upon.

LEON GASTER.

Review of Contents of this Issue.

MR. F. GÖHRUM (p. 7) contributes an article on the **Aesthetic Aspects of Street Lighting**. He urges that the qualities which were considered æsthetic in times gone by depended chiefly on tradition, whereas nowadays the factor "suitability for the purposes in view" is equally important. He traces the development of street lighting from the "beacon" system to that of the present day, and claims that incandescent gas fulfils æsthetic requirements more completely than the electric arc as regards colour, steadiness, and ability to produce even illumination.

Following this (p. 10) will be found an account of a recent paper on **Street Lighting by Modern Electric Lamps** read by MR. HAYDN T. HARRISON before the Institution of Electrical Engineers on November 24th, and the discussion. In this paper the value of Tungsten lamps for side street lighting and the advantages possessed by special forms of reflectors are pointed out. By this means very uniform illumination is secured. Tabulated data regarding costs and the distribution of light from various classes of lamps are also given.

In the discussion several speakers gave their experiences of electric street lighting in their locality. Stress is laid on the avoidance of glare, and the suggestion is brought forward that a model **Specification for Street Lighting** is badly needed.

PROF. W. C. CLINTON (p. 19) contributes the third of our series of articles dealing with photometric laboratories in different countries. In this article he describes the **Photometric Laboratory at University College** (London), giving particulars of the apparatus used for testing glow lamps, obtaining polar curves of light distribution, &c. Particulars are also given of some tests of standard glow lamps in this country and in Germany which led to very consistent and apparently accurate results.

The section of the journal devoted to the transactions of the Illuminating Engineering Society contains an account of the last meeting on December 9th when the paper entitled **Recent Progress in Electric Lighting** was read by PROF. E. W. MARCHANT (p. 29). A very important announcement was made by the President to the effect that the Council of the Illuminating Engineering Society had resolved to appoint a Committee to deal with the question of **A Street Lighting Specification.**

Prof. Marchant's paper and the complete discussion will be found on pages 29–49. The paper is mainly devoted to a summary of the progress in different types of electric illuminants, glow lamps, arc lamps, and vapour lamps, &c. The results of some **Life Tests on Metallic Filament Lamps** are given, and also an account of some experiments on the effect of an intermittent current upon life and efficiency; this last test appears to show that the lamps are not prejudicially affected by being constantly turned on and off.

A description is also given of a number of different forms of **Flame Arc Lamps,** and some tests are described on the "diversity coefficient" resulting from the use of flame arcs at a prescribed distance. Other experiments described include tests on the **New Quartz Tube Mercury Vapour Lamp,** of which the polar curve of light distribution is given. In conclusion Prof. Marchant describes the construction of an Ulbricht sphere, which he had utilized in making the tests of arc lamps referred to above.

Subsequently a contribution from PROF. G. W. O. HOWE was presented (p. 38). Prof. Howe describes some experiments on the **Blackening of High-Candle-Power Osram Lamps** at the Central Technical College. It was found that the blackening was very uneven and apparently derived from the point where the leading in wires were joined to the filament. A copper coloured deposit was formed round the base of the bulb and, on test, proved to consist mainly of copper. The chief peculiarity, however, was the formation of an image of the filament and support upon the glass bulb, owing, presumably, to projection of particles from the point alluded to above.

In the discussion THE PRESIDENT expressed a desire that conflicting commercial interests should be excluded from the discussion; he also referred to Dr. Sumpner's box photometer, and to the effect on the colour of light absorbed in the atmosphere. This absorption tended to cut out the blue and violet rays from the spectrum. MR. A. P. TROTTER referred to the need for lamps of smaller candle-power, and described the use of an acetylene lamp with a blue screen to produce a light closely resembling daylight. MR. HAYDN T. HARRISON raised the question of the correct method of measuring the mean hemispherical candle-power. MR. A. H. SEABROOK laid stress on the value of scientific reflectors as a means of securing good illumination from Metallic Filament Lamps. PROF. J. T. MORRIS also referred to the value of reflectors used with glow-lamps in securing uniform illumination in drawing offices. MR. H. D. WILKINSON expressed doubt whether perfectly uniform illumination was desirable in street lighting. MR. JUSTUS ECK criticised the author's figures for flame arc lamps, stating that, in his experience, it was possible, under practical conditions, to secure a diversity factor of only 2·5 to 1. He added that flame arcs were being extensively used in drawing offices and for lighting large interiors.

MR. L. GASTER referred briefly to the historical development of metallic filament lamps and emphasized the need for standardization of their dimensions. MR. W. R. RAWLINGS raised the question of the effect of voltage variation on lamps. MR. P. J. WALDRAM pointed out the value of light-tinted walls and ceilings as a means of obtaining uniform illumination.

PROF. E. W. MARCHANT briefly replied, and the President made some concluding remarks in which he described, among other matters, the magnetite arc.

Another article of interest in connexion with the progress in electric lighting is that on p. 23, in which a summary is given of recent developments in **Methods of Manufacturing Metallic Filaments**.

Following this will be found some further contributions replying to the series of **Queries on Gas Lighting** published in the last number. DR. C. R. BÖHM (Berlin), and MR. C. O. BOND (Philadelphia) give their experiences on the various points raised.

An article on p. 18 contains a description of a method of **Lighting a Bowling Alley**; in this case the chief object is to produce an illumination which gradually increases towards the spot where the skittles are stationed. Special precautions are necessary to keep the lights out of the field of view of the players and to avoid reflection of a glaring nature from the polished floor.

Another matter of some importance is the series of recommendations issued by the London County Council with regard to the supervision of electric lighting decorations, &c. (p. 9). This is of special consequence in view of the fact that illuminations of this kind are expected to play an important part in the Coronation festivities next June.

There will next be found the usual **Short Notes on Illuminating Engineering**, in which a number of subjects of interest are briefly treated. Following this are the **Correspondence**, a series of **Trade Notes** (dealing mainly with electric lighting), and the usual **Review of the Technical Press.**

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Some Æsthetic Aspects of Public Street Lighting.

By F. Göhrum (Chief Engineer of the Municipal Gas Works, Stuttgart).

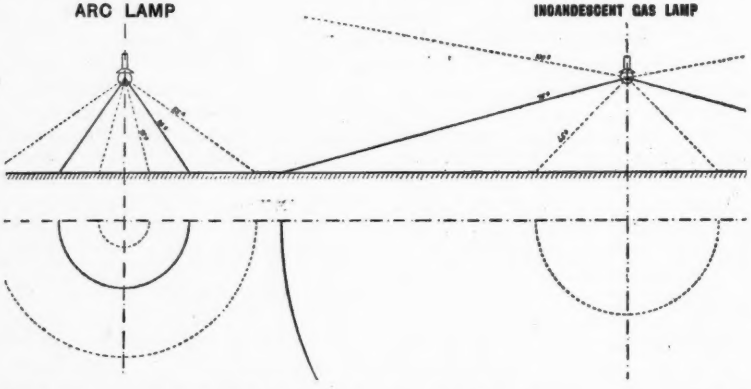
When, in these days, discussions arise on the subject of the æsthetic aspects of lighting, one cannot fail to be struck by the modification that has taken place in the standpoint from which this matter is regarded. In earlier times æsthetic impressions were mainly coloured by inherited tradition; to-day it is very largely the conception of an object as being fitted for the purpose in view that determines its æsthetic qualities. No doubt this is to be mainly ascribed to the growing influence of scientific ideas, and study on all modern conditions of life. Hence it comes about that the æsthetic aspects of public lighting are bound up with the question, what ought the object of such illumination to be?

I have shown elsewhere that until comparatively recent times men knew little or nothing of street illumination in the sense that we know it to-day; they only attempted to indicate important points in the streets by sparsely spaced oil lanterns and the like. In the few cases in which regular street lighting was attempted lanterns of this kind—"beacon-lights"—were regarded as sufficient. It was only afterwards that the invention of more powerful artificial illuminants, and their application to the illumination of interiors by night, led to the conception of artificial lighting as a substitute and imitation of daylight; and it was later still that this idea came to be eventually applied also to outdoor public lighting. It was only in the case of streets of a certain size, and in towns in which the industrial conditions served to emphasize the necessity of security of life and property against evil-doers, that adequate street lighting was even attempted. Moreover, it came to be appreciated that the illumination depended very greatly on the nature of the traffic, &c., and thus various towns adopted different conditions of lighting according to the local conditions and needs in this respect. Finally (rather according to the wealth and demands for comfort on the part of towns than with regard to their size), a standard of illumination came to be adopted in some streets considerably in excess of that which considerations of safety and police requirements, or mere visibility of surroundings, would demand. In what follows this final stage of what may be termed "superabundant illumination" will be assumed.

What are the requirements of illumination of this kind? The ideal conditions would be those characteristic of good daylight—not direct rays from the unclouded sun, but the even illumination of surroundings, without hard shadow, the mild illumination from the diffusing sky. We see, therefore, that the ideal conditions of illumination aimed at in the streets are similar to those regarded as most perfect in the case of such interiors as drawing offices, lecture halls, &c. Until the invention of powerful lamps the production of outdoor artificial illumination of this kind was out of the question (in interior lighting the same

effect could be more readily produced by the indirect method of lighting or by the utilization of a large number of distributed lamps of small candle-power).

First of all the electric arc-lamp appeared upon the scene, and for a time furnished the only acceptable illuminant to meet the required conditions. Subsequently, however, the introduction of powerful gaslights enlarged the choice available. But just as the increased cost of street lighting by more powerful units proved no obstacle to the introduction of the electric arc-lamp, so to-day the question of cost will be found to play a relatively small rôle in the case of streets in which the prime object is to produce an impression of great comfort and brilliancy.



We have seen that the ideal method of street lighting would be a system resembling diffused daylight, and the question may now be raised which of the two illuminants, gas or electricity, enables these conditions to be most nearly approached. In the first place one would naturally select the illuminant the spectrum of which approached most nearly to that of diffused daylight. Arc-lamps with ordinary carbons yield only approximately white light. The so-called flame arc-lamps can be arranged to give colours varying from pearl white to red, according to the nature of the chemical constituents added to the core; yet the resemblance to daylight is again only approximate. The high-pressure gaslight, on the other hand, can be made to yield an exact resemblance to daylight, a slightly warmer tint can be added by suitably modifying the proportions of cerium and thorium in the mantle. On the ground of colour the incandescent gaslight should therefore be regarded as preferable to the electric light.

A further characteristic of a diffused daylight is the uniformity with which the surroundings can be flooded with light. This again is due to the extraordinary distance of the sky and sun from the earth. We cannot reproduce this condition exactly by the use of either of the two illuminants considered. In neither case can we secure a source approaching the candle-power of the sun, nor can we indefinitely increase the height of suspension. Consequently the completeness with which we can approach uniform illumination depends very largely on the *nature of the distribution of light* in the two cases.

Now in the case of the electric arc-lamp the maximum candle-power is located at angles from 15° to 55°, on the average about 35° to the vertical; in the case of the incandescent gaslight, on the other hand, the maximum occurs near 45°–100°, on the average 75° to the vertical. As a result it is easier to secure approximate uniformity of illumination in the latter case.

In order to improve electric arc lamps in this respect it has been customary to provide them with outer

diffusing globes, and to hang them at a considerable height. If no such globes are utilized the height of suspension must be increased still further.

The illustration on the opposite page shows the ability of the gas lamp, owing to its good natural curve of light-distribution, to spread its light over a relatively extended area in the street.

Another good feature of the incandescent gas light is the steadiness of the illumination. In this respect the arc lamp is certainly not so satisfactory, for it is well known that considerable fluctuations do occur which, in the case of flame-arcs, may reach 20 per cent or more, and give rise to a very unpleasant effect. In this respect also, the electric arc lamp seems to exhibit a departure from normal diffused daylight.

To sum up, therefore, it appears that the incandescent gas light approaches diffused daylight most closely, and this complies most nearly with the æsthetic requirements of street illumination. This consideration, quite apart from the question of cost, should be regarded as favourable to incandescent gas in deciding problems of this nature.

Electrical Illuminations and the L.C.C.

In view of the enormous number of electric lights which will be used for illumination purposes when the King is crowned next June, the Fire Brigade Committee of the L.C.C. have drawn up a set of recommendations to which they desire that publicity shall be given in electrical circles. The L.C.C. has, of course, no power to enforce these recommendations, nor does it possess any direct jurisdiction, but it suggests that each local authority might inspect the temporary illuminations put up in its own district, and it believes that the co-operation of all electric supply undertakers will be forthcoming. The suggestions run as follows :—

1. All installations should be inspected, tested, and approved by the local supply authority before connexion is made, and any installation that has not a satisfactory insulation between poles, and between either pole and earth, should not be connected.

2. All circuits and sub-circuits should be provided with properly proportioned fuses to each pole ; and sub-circuits should be limited to a maximum of (say) two kilowatts each, and should be arranged with due regard to current density in the conductors.

3. No bare conductors should be used, and all conductors within reach of the public should be specially protected by suitable conduits ; and all metal conduits or coverings should be efficiently "earthed."

4. All switches, fuses, terminals, and connectors should be protected from effects of weather and from possibility of mechanical injury.

5. Festoons, garlands, &c., containing lamps should be provided with means of support independent of, and insulated from, the conductors, and should be secured in such a manner as to minimize risk of injury from wind.

6. All shades and decorations of combustible materials in proximity to lamps should be rendered non-inflammable by a process which will withstand the action of rain for several days, and no shades or decorations of celluloid or similar substance should be used.

7. The installations should be connected, where practicable, at the main intake, or at the main distribution boards, so as to avoid the possible overloading of the house wiring.—*Electrical Times*, Dec. 1, 1910.

Street Lighting by Modern Electric Lamps.

By Haydn T. Harrison, M.I.E.E.

(Abstract of paper read before the Institution of Electrical Engineers, London, November 24th, 1910.)

In the early days of street lighting, engineers were greatly hampered by the fact that there were only lamps of relatively high candle-power and consumption of energy available, and in many cases the light was mainly thrown out in directions which are not convenient for obtaining uniform distribution of light. Moreover, as Dr. Louis Bell has pointed out, "Street lighting has been a growth and an evolution, but like all growths it has proceeded along the lines of least resistance; lamps were put, not in the best places for them, but where they could be put in with the least disturbance to individuals." The engineer of to-day is often in the same position, of having to adjust and increase the c.-p. at certain prescribed points, using the same existing lamp-posts, but he has at his disposal a much greater variety of lamps of a much wider range of candle-power, and possessing polar curves of light distribution much more convenient than those characteristic of many arc-lamps in the past.

As an illustration of such a conversion Marylebone, where incandescent gas lamps have been replaced by tungsten electric ones, is taken. Each lantern was equipped with two 115 volt 35 c.-p. Osram lamps, the natural polar curve of which is a good one for street lighting purposes. It was, however, modified by the adoption of the well-known wedge-shaped diffusing reflector placed above the lamp, which assisted the distribution of the light in the desired direction, and was beneficial as a means of reducing glare; the intensity of the horizontal ray was practically doubled. The price charged per unit in this case was 1·42*d*.

Mr. Harrison added that in 1905 he had given the average minimum illuminations in the streets in provincial towns as follows:—

Main thoroughfares 0·05 c. ft.
Side street, 0·025 c. ft.
Suburban streets, 0·005 c. ft.

Now in Marylebone, in 1909, the average minimum illumination was 0·15 c. ft. in the case of main thoroughfares, and 0·048 to 0·07 in the case of side streets. The cost per mile in the two cases, taking electrical energy at 1·42*d*., would be:—

Main thoroughfares, £384 per mile.
Side streets, £204 per mile.

In Oxford Street the minimum horizontal illumination was 0·11 c. ft., and the cost per mile per annum £800.

Proceeding, Mr. Harrison remarked that since that time a step in the right direction had been made by the introduction of dioptric globes, which redistributed the light in directions favourable to street illumination. Vertical carbons were spoken of with approval from the standpoint of improved efficiency and better distribution; however, they gave a less steady light, and differences as great as 50 per cent had been encountered by the author. Another important point was the absorption of globes, which differed among themselves enormously in this respect.

Table I. was then presented by Mr. Harrison showing the relative efficiencies of different street lamps, bearing in mind the nature of the globes used.

Although such marked improvements have been made in arc-lighting, there are many districts in which lamps characteristic of the very early days of electric lighting are still used. For example, in districts bordering on Marylebone there are stretches of

streets in which the illumination is less and the cost higher. Moreover, in one instance the cost of lighting of 25 miles of streets is nearly £880 per mile per annum, and the minimum illumination 0·05 c. ft. On referring to the Marylebone figures, where the same class of street is illuminated by the first, and sometimes triple, the cost does not exceed £204 per mile.

The series of figures shown in Table II. relating to the cost of various forms of lamps are also interesting.

Mr. Harrison suggests that these results show that, except in very important streets, tungsten lamps,

TABLE I.

Candle-power per Watt of Various Lamps at 10° to 15° from Horizontal.

Type of Lamp.	Watts per Lamp.	Candle-power per Watt.	Type of Globe.
Tungsten	From 40 upwards	0·8	Clear glass
Grouped Tungsten Lamps...	300	1·5	In specially designed fittings
Open arc	500	0·7	Standard opalescent
Enclosed arc, direct current	460	0·5	Clear inner and outer globe
Excello flame arc	460	2·4	Standard opalescent
Excello flame arc	460	3·7	Dioptric and opalescent
Excello flame arc	550	6·5	Dioptric and clear
Jandus Regeneration ...	360 to 460	5 to 8	Standard globes
Magazine lamp	350	2·0	Standard globes
Magazine alternating .	440	1·6	Standard globes

means of the tungsten lamps, it will be found that a minimum illumination of 0·08 c. ft., nearly half as much again, is obtained at a cost of £414 per mile, or less than half. In the other neighbouring district the arc-lamps are spread over nearly 37 miles of streets, and are arranged to give two different degrees of minimum illumination, namely, in the important thoroughfares 0·012 c. ft., and 0·008 in the lesser thoroughfares; at the prices charged this works out at about £450 and £350 per mile respectively. Compare this with Marylebone, where the illumination even of the side streets is more than double

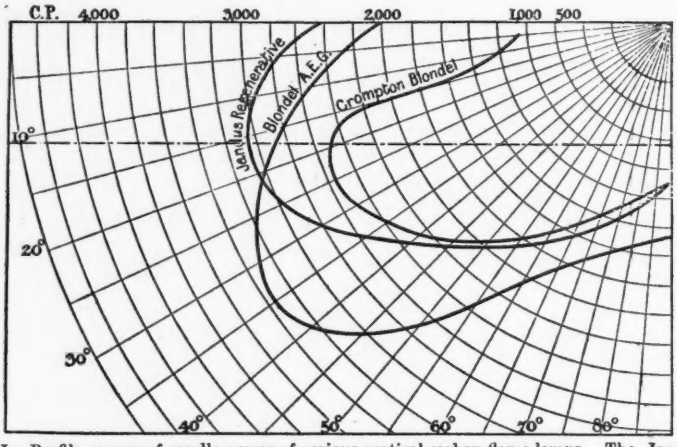
judiciously used, give better results than arc-lamps. He cites Croydon and Harrogate as other localities in which the use of tungsten lamps has been found beneficial. In these cases the reflector is designed specially with a view to good distribution of light, but the avoidance of glare is a second equally important consideration. It is satisfactory, as showing the more enlightened views of town councils nowadays, to find that in Mr. Harrison's experience they almost invariably select as the lamp giving the most light that in which there is least glare.

TABLE II.

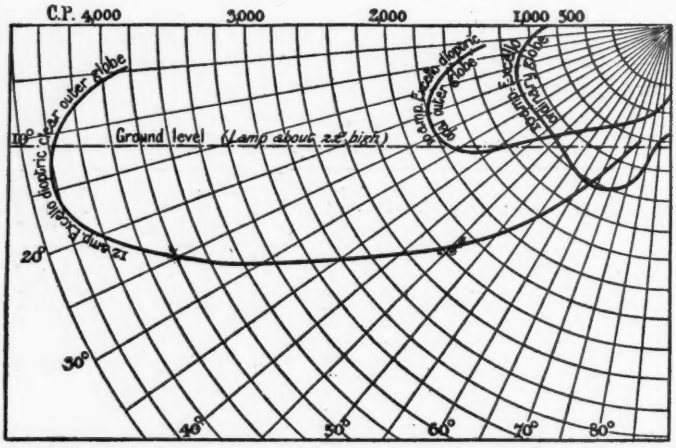
Total Cost per Candle-power per Annum.

	Candle-power of Light Unit.	Cost per Candle-power per Annum (Total). Naked Lamp.	Cost per Candle-power per Annum in Special Lantern.
		d.	d.
A	50 tungsten	10·50	7·0
A	100 tungsten	8·20	5·0
A	200 tungsten	7·00	4·3
A	300 tungsten	6·66	4·1
A	400 tungsten	6·50	3·8
A	500 tungsten	6·40	3·5
B	300 open arc	10·20	–
C	1,000 flame arc	3·65	—
C	3,000 flame arc (dioptric and clear outer) ...	1·32	—
D	2,000 to 4,000 regenerative flame	1·0 to 0·8	—

Thus it will be seen that a specification that relies only on candle-power of illumination does not always result in the greatest satisfaction to the public. it is done by the wedge-shaped white surfaces above the lamps being brought down as near the filament or light source as possible. A very ingenious



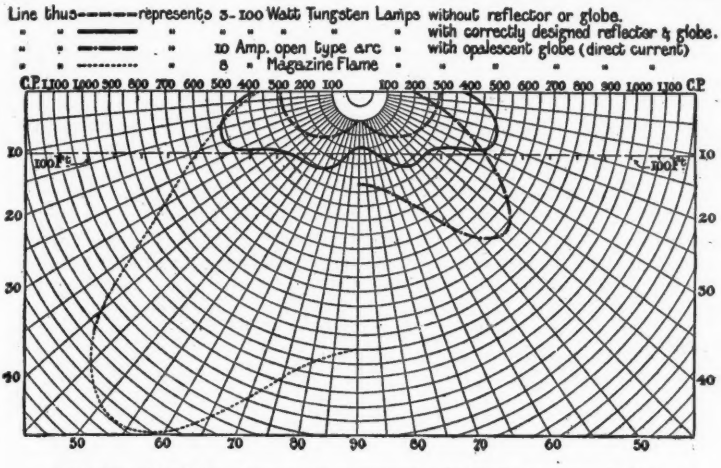
CURVE I.—Profile curves of candle-power of various vertical carbon flame lamps. The Jandus and Blondel A.E.G. are long burning lamps. These curves are taken from figures issued by the manufacturers, but are chosen from lamps taking approximately the same watts and having opalescent or similar globes.



CURVE II.—Candle-power at various angles of flame arc lamps, showing effect of dioptric and other globes. These are the results of several photometric measurements made by the author in Regent Street, Oxford Circus, and Oxford Street. It should be noted that the lamps in Regent Street, with the dioptric and clear globes, are taking 12 amperes, whereas the others are 10-ampere lamps.

There are many ways of reducing the deleterious effect of high intrinsic brilliancy of light sources, without interfering with the efficiency of the light. In Marylebone, for instance, method has lately been invented by Mr. Pragnall, based on the principle that nearly all light sources cover an appreciable area, thus by fixing thin sheets of metal having white surfaces,

adjacent and radially to the light source, it is seen in the midst of an illuminated white surface, and not against the dark sky or distant surroundings, while at the same time practically no light is lost owing to the surfaces being thin and radial to the lamp.


Line thus ——— represents 3-100 Watt Tungsten Lamps without reflector or globe.
" " ——— " " " " " " with correctly designed reflector & globe.
" " ——— " 10 Amp. open type arc " with opalescent globe (direct current)
" " ---------- " 8 " Magazine Flame " " " " " "
C.P. 1100 1000 900 800 700 600 500 400 300 200 100 100 200 300 400 500 600 700 800 900 1000 1100 C.P.
100 Ft.
100 Ft.
10
20
30
40
50 60 70 80 90 80 70 60 50

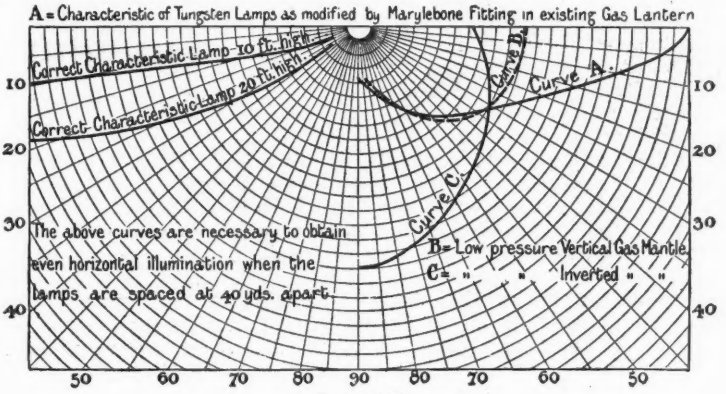
The horizontal dotted line shows position of pavement to light angles for lamp 20 ft. high.

Note that the tungsten lamps with reflector give higher illumination than the open arc at any distance exceeding 50 ft. than the flame arc at any distance exceeding 120 ft.

[These curves are plotted from measurements made in the street.]

CURVE III.

Mr. Harrison then proceeded to refer to the specification for street lighting drawn up for the Westminster Council and detailed in Mr. Abady's recent paper.* It will be recalled that the method adopted involves the determination of mean hemispherical candle-power as the average of the intensities at 20° and 50° to the horizontal. Mr. Harrison, however, points out that a firm might tender on the basis of this specification by utilizing glass globes such as gave 3 to 5 times as much light in the 50 direction as in the 20; this would mean a curve of distribu-


A = Characteristic of Tungsten Lamps as modified by Marylebone Fitting in existing Gas Lantern
Correct Characteristic Lamp 10 ft. high
Correct Characteristic Lamp 20 ft. high
Curve D.
Curve A.
Curve C.
The above curves are necessary to obtain even horizontal illumination when the lamps are spaced at 40 yds. apart
B = Low pressure Vertical Gas Mantle.
C = " " " Inverted " "
10
20
30
40
50 60 70 80 90 80 70 60 50

CURVE IV.

* *Illum. Eng.*, Lond., vol. iii., July, 1910, p. 344.

tion very unsuitable to street-illumination and yield a very low minimum.

The chief requisite of good street lighting is uniform illumination. Mr. A. J. Sweet has given the permissible ratio of maximum to minimum as 4:1. In Oxford Street, using flame arcs, the figure is 99:1. In Regent Street, using the same form of lamp, 13:1. In Victoria Street, where high-pressure gas lighting has just been installed, it is 20:1. In the important streets of Marylebone, on the other hand, it is only 6:1. It is the possibility of using special globes and reflectors with incandescent lamps that gives them such a substantial advantage as regards light distribution.

In conclusion, Mr. Harrison lays stress on the importance of avoiding glare. "In this connexion," he remarks, "the eyesight of the present generation is suffering from the indiscriminate use of large glaring light units, unsuitably placed. Therefore it is important that those who are called upon to illuminate streets, where the minimum illumination cannot exceed 0·1 of a candle-foot, should not be tempted to accentuate this low figure by producing a few patches of bright light."

The concluding sentence of the paper also deserves special mention :—

"I should like to take this opportunity of warning engineers that good illumination, though the prime object in street lighting, is not the only feature to be considered. Careful thought must be given to obtaining as even illumination as possible ; and if high intrinsic brilliancy is carefully avoided the result will be in every way satisfactory, not only to the lighting authorities, but also to the general public."

Discussion.

Mr. Frank Bailey said that street lighting ought to be considered from the standpoint of *how much* illumination was needed, not purely as a matter of cost. At present its importance as a public matter was not recognized, and cheapness was too much the predominant motive. His own company, in trying to secure improvements, were constantly met by this attitude. There was a difficulty in securing the desired kind of fittings, and Mr. Harrison had done good work in this direction ; on the other hand, metallic filament lamps were not suited for the illumination of all kinds of streets. There was a need for some authoritative specification on the subject of street lighting.

Mr. C. P. Sparks suggested that the Institution of Electrical Engineers should appoint a Committee to draw up such a specification on broad lines. He agreed as to the necessity for a lower "diversity factor." Greater uniformity in illumination was wanted. Public lighting was largely in the hands of municipal bodies, and some stimulus was often necessary to induce them to renovate old fittings. He thought the price of 1*d*. per unit high for large cities.

Mr. A. H. Seabrook commented upon the divergence of the figures for gas lighting presented by Mr. Harrison as compared with others put forward, and referred to Mr. Harrison's valuable work in connexion with street lighting problems. Unreasonable difficulty was often experienced in securing the sanction of loans, for street lighting purposes.

Contrasting the lighting of Regent and Oxford Streets, Mr. Seabrook added that the effect seemed to him more glaring in the former case. He was disposed to favour centre columns for wide streets.

Mr. W. A. Vignoles (Grimsby) said that in Grimsby the L.G.B. had sanctioned a street lighting loan for ten years. He thought too much importance might be attached to uniformity. It seemed preferable to allow a certain amount of spottiness if the general total illumination was improved as a result. Again dioptric globes, while improving uniformity, seemed

to give rise to a certain amount of glare. He favoured central suspension of arc-lamps when possible. In Grimsby, where enclosed flame arc-lamps 84 yards apart were used, the cost was £400 per mile.

MR. A. P. TROTTER said he was glad to note the recognition of the importance of the diversity factor; 30 years ago he had designed dioptric globes in order to distribute the light more perfectly. The lighting of side streets was an important matter, and one that called for considerable skill.

MR. LEON GASTER remarked that in the very early days of street lighting every householder was compelled to hang out a lantern. The main conception of street lighting then was security, and illumination is still regarded as a valuable assistance to the police. The great development in high speed traffic of late years had furnished another powerful claim for good illumination, and he suggested that a portion of the sum contributed to road maintenance by the owners of motor vehicles might profitably be expended on improved lighting. It was not only good illumination that was needed; absence of glare was quite as important. The matter should also be of interest to the newly created traffic board. He entirely approved of the suggestion for a Committee to deal with street lighting specifications, but it should be thoroughly representative of the different interests concerned. The Verband Deutscher Elektrotechniker, in Germany, had drawn up a specification, applicable both to indoor and outdoor lighting, for acceptance by electrical engineers, and this has been submitted to the German Institution of Gas Engineers for approval.

MR. W. R. COOPER took exception to the use of the term "diversity factor," and raised the question how far an exact meaning could be attached to the "candle-power" of such objects as dioptric globes, which were not true radiating point sources.

MR. C. M. SHAW (Worcester) said that he had found gas lanterns could rarely be satisfactorily converted for use with electric lamps. In Worcester the cost per mile per annum was much less than the figures quoted by other speakers—only about £120. They had also tried the use of overhead mains along the tramway poles. Metallic filament lamps, hung 16 ft. above the ground, were used. They gave very little glare and no patches, and had given great satisfaction.

PROF. J. T. MORRIS laid stress on the need for diminishing glare. To secure this end all lamps should be screened at angles less than 10 to 15 degrees below the horizontal. In Marylebone the use of reflectors had materially assisted the diminution of glare. Prof. Morris also gave some figures for the effect of various lamps on the pupil-aperture.

Among other speakers who followed: MR. C. NEWTON RUSSEL (Shoreditch) referred to the substitution of metallic filament lamps for gas lamps in his locality. MR. KENELM EDGCUMBE expressed approval of the suggested Committee on Street Lighting Specifications, and added that it should include representatives of the gas industry, surveyors, &c. MR. H. BOOT suggested the central suspension of sources in very narrow streets, and thought that the prices assumed for energy were too high. The actual cost was under $\frac{1}{2}d$.

MR. J. S. DOW pointed out that it was necessary to compromise between securing absolute uniformity in illumination and absence of glare. It was also desirable to encourage private local illumination—illuminated signs, &c.—in the streets, and to aim at obtaining surfaces of moderate brightness as a background to the lamps themselves. The suggested Committee might do valuable work, and should receive the support of the Illuminating Engineering Society.

MR. HAYDN T. HARRISON in reply agreed that the increased speed of traffic demanded better illumination. He did not entirely approve of central lighting, as it might lead to lights shining direct into the eyes of drivers, &c. It was a pity that every householder could not be induced to hang out a light now, as in the past, as this subdivision of lighting was what was

wanted. In connexion with the suggested specification, he thought the co-operation of the gas industry and the surveyors should be secured. Surveyors required education in street lighting matters. He strongly advised all those interested in the subject to join the Illuminating Engineering Society, where they would get much useful information. He agreed that 1*d.* per unit was high, but it was usually difficult for an engineer to convince his Committee of this fact. He could not agree with Mr. Vignoles that a good diversity factor was not important. The "seeing effect" in lighting depended largely on the avoidance of excessive contrast. He reminded Mr. Shaw that tramway pole lighting meant fewer posts per mile. Thus in Worcester there would be only 44 as compared with about 65 in Marylebone. Mr. Harrison also dealt with other points of detail, referring the speakers to the exact wording in his paper.

—•—

Mr. E. Kilburn Scott has also communicated to us some remarks on this paper. He considers that central posts are dangerous, and that lamps suspended on wires spanning the street are also objectionable. The ideal method, he suggests, is for the lamps to be attached on brackets to private buildings. This would not really involve much hardship on the owners of the buildings referred to who have already frequently to put up with electric lamps on posts quite near to their walls. In conjunction with this method the portion of the wall to which the bracket is attached could be whitened so as to reflect light into the streets and provide a valuable mitigation of glare. It would also be possible to attach the names of streets, and—if sufficiently important—of buildings also, beneath these lamps so that they are effectively illuminated by night. At present strangers experience the very greatest difficulty in finding their way about London; the evidence of the American sailors now on visit would bear out this point! In spite of the improvement of street lighting the present conditions, in view of the increased traffic, still leave much to be desired, the illumination round the churches and islands being often particularly defective. An interesting situation has arisen in Bromley, Kent. In that town both the gas and electricity are owned by private companies. The Municipality has a contract with the gas company for the street lighting. The tradesmen in the High Street, however, being dissatisfied, determined to enter into a private contract with the Electric Lighting Company, and appointed a committee to deal with the matter. They have now decided to attach electric lamps to the walls of their buildings, and have entered into a contract with the electric company for this to be done. There is a tendency for everything to be shouldered on to the local authorities nowadays, and it seems possible that in many cases there would be room for individual action of this description.

The Lighting of Piccadilly.

The illustration on the opposite page shows the lighting of Piccadilly, London, by night. The view is one of many interesting ones recently published in the special lighting number of *The Electrical Times*, to whom we are indebted for the use of this illustration. In passing it may be remarked that the issue of an elaborate number of this nature, devoted specially to street lighting, suggests that there is an ever-growing desire for more information on lighting matters.

An interesting feature of this view is that it shows up the important role played by private lighting in many of the west-end centres. It is said that in the United States lavish private lighting often adds greatly to the available illumination

View of Piccadilly (London) by Night. [By the courtesy of *The Electrical Times*.

in the streets, and merchants occasionally club together to make special provision of light in order to attract traffic to their neighbourhood. In London it is, as a rule, only in the entertainment centres that private lighting forms such an important feature.

Another point to be noted is the assistance rendered by the good reflecting power of some of the buildings. It seems to be a fact that the tendency to "glare" in the lighting of some London streets is in no small measure due to the griminess of the buildings which present a dark background against which the lamps appear to the eye, by contrast, more intensely bright than they otherwise would do. The loss of light by absorption is also considerable, and, in short, a smoke-laden atmosphere is a distinct disadvantage from the illuminating engineering standpoint. Illuminating engineers, therefore, as well as others, will have reason to be thankful when the efforts to get rid of the smoke nuisance are finally crowned with success.

The Lighting of a Bowling Alley.

THIS is another example of specialized lighting, in which the important features to be observed are the avoidance of glare combined with brilliant illumination of the alley, especially at the distant end. The writer when visiting some of the skittle alleys in this country was recently struck by the careless methods of arranging the lighting. The illumination was obtained from unshaded lights placed directly between the person bowling and the nine-pins at the other end, and must have considerably hampered the player, and been especially liable to provoke weariness by the end of an evening's play. We are indebted to the *Edison Monthly* for the illustration given here of a Bowling "Academy" in New York. It will be noted that the lights above the floor are completely shaded so that no direct light strikes the eye of the bowler, and the reflectors give a well diffused general illumination over each alley. The reflection from the polished floor, however, seems to be rather an objectionable feature, but this defect would appear somewhat hard to eliminate completely.

Some Well-known Photometrical Laboratories.

III.—The Photometric Equipment in the Pender Electrical Laboratory of University College, London.

By W. C. Clinton, B.Sc.

At the time when University College and King's College were incorporated as constituent colleges of the University of London, it was desired as far as possible to prevent overlapping in the scientific and teaching work of the two institutions, and with this object in view it was arranged that certain departments of post-graduate and scientific work should be particularly conducted at each of these colleges.

In connexion with the engineering departments one of the subjects which it was arranged should be specially provided for at University College was the important one of photometry. A considerable amount of work in this direction had been done in previous years in the Pender Laboratory, as described by Dr. J. A. Fleming, F.R.S., in a paper read before the Institution of Electrical Engineers on December 11th, 1902, entitled 'The Photometry of Electric Lamps,' and advantage was taken of this experience when the recent rearrangement of the Electrical Engineering Laboratory at University College permitted a room being set apart for photometric research, and equipped with the most modern appliances for the accurate photometry of illuminants.

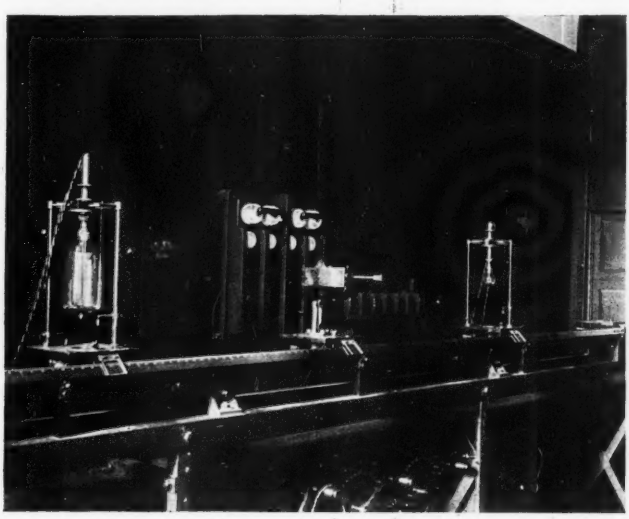


Fig. 1.—General Arrangement of Photometer Bench.

The room selected is on the ground floor of the south wing of the College, and is lit by a single large window giving a north light. This window is fitted with a case containing a roller blind of opaque black cloth, capable of excluding all daylight from the room. Ventilation is effected by a screened fanlight over the door.

The room is 19 ft. long by 9 ft. 6 in.

wide, and about 15 ft. high, allowing of the erection along one side a photometric bench having a scale 14 ft. long. On the other side of the room are tables, one of which carries the potentiometer outfit. Connexion is made to the lamps on the bench by leads carried up the walls and across the ceiling.

The general arrangement is shown in Figs. 1 and 2.

The photometric bench consists of two lengths of steel tube $1\frac{1}{2}$ inches in diameter, rigidly supported parallel to one another in a horizontal position on wrought iron frames let on a carriage, the lamp filament hanging downwards. Adjustments are provided to bring the filament into agreement with the reading wire attached to each carriage, and running just clear of the bench scale.

It is now generally recognized that the most important thing to be determined photometrically about any source of light is its polar curve of illumination in any given plane, and that elaborate arrangements for the determination of any kind of mean candle-power by one observation are not worth the trouble of setting up. All lamp-holders have therefore been so designed

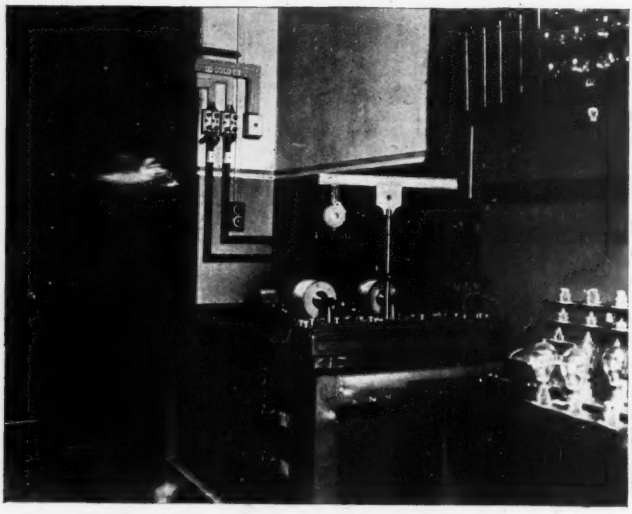


FIG. 2.—Arrangement of Potentiometer Table, &c.

into the concrete floor. Running on these tubes as guides, are three-wheeled carriages, each consisting of a rectangular flat table of aluminium, fitted with one clamp for fixing its position on the guides and another for attaching it to a thin endless steel cable which runs the whole length of the bench under the carriages, and is carried on friction wheels at the ends. There are holes in the carriage tables which allow of any apparatus being fixed to them.

Electric incandescent lamps are suspended from a light stiff framing of steel tubing and aluminium mounted that the candle-power of the suspended lamp can be determined in any desired direction.

In the matter of standards of light, provision has been made for the use of the 10 candle Harcourt Pentane Standard, but reliance is chiefly placed on the known constant value of the candle-power of each of a set of Fleming large bulb electric incandescent standards possessed by the laboratory.

The history of one of these lamps known as Pender III. has been given from its manufacture in the year 1895 up to the year 1902 by Dr. Fleming

in the paper already referred to. From October, 1896, to June, 1903, this lamp was taken to give 12·75 candle-

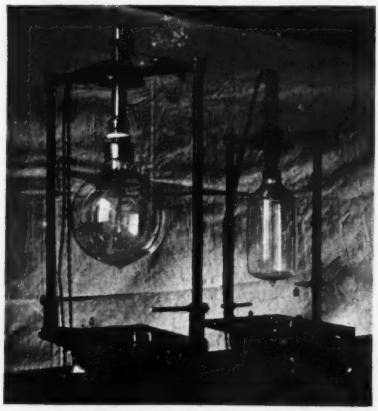


FIG. 3.—Travelling Carriages on Photometer Bench.

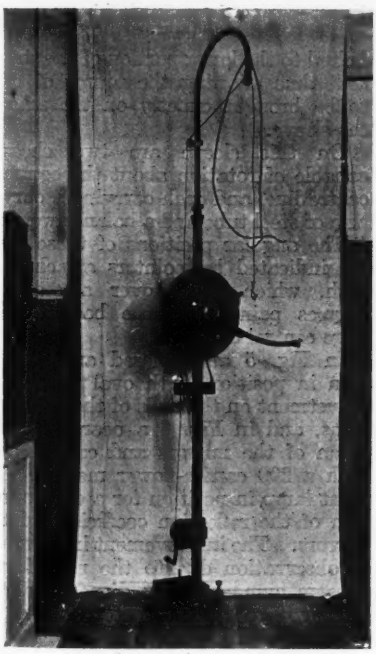


FIG. 4.—Fixed Lamp Carrier.

power at 96 volts. In July, 1903, fresh determinations were made against a new 10 candle Harcourt Standard in the laboratory, set up in accordance with the instructions given in the Gas Referees' notification of 1901. Two sets of fourteen readings each were taken on different days, the mean value of the candle-power at 96 volts being 12·59 and 12·91. The mean of these two, 12·8 compares with the value 12·75 obtained in 1895.

In June, 1904, the rating of Pender III. was altered to 12·28 candle-power at 96 volts in order to agree with the standards in use at the National

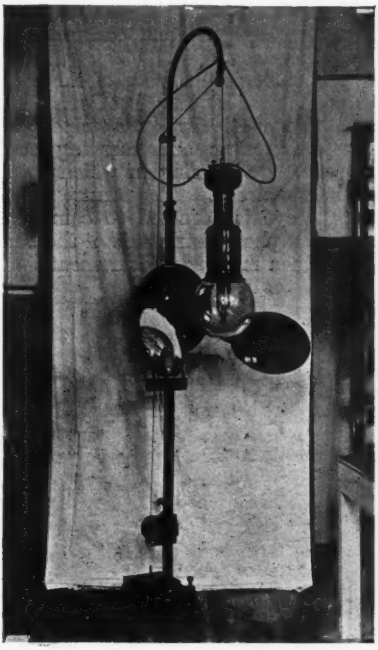


FIG. 5.—Lamp Stand Carrying Arc Lamp.

Physical Laboratory, and in December, 1909, it was compared at this rating with two lamps having Reichsanstalt and National Physical Laboratory certificates. The candle-power of these two lamps according to the three several authorities are :—

Reichsanstalt	National Physical Laboratory.	University College Laboratory.
14·58 15·39	14·45 15·50	14·42 15·52

It is safe to conclude therefore that the candle-power of this lamp has remained measurably constant over an interval of 15 years.

This is a striking confirmation of the opinion long held by Dr. Fleming that the best secondary standard of light is a properly constructed large bulb glow-lamp.

For the determination of distribution curves from large units of light it was found that a portable form of lampholder was desirable. The arrangement adopted to meet this requirement is that illustrated below, and was designed and constructed in the laboratory.

Figure 4 gives a view of the stand, consisting of a length of steel tube mounted vertically on a tripod with levelling screws and carrying at its upper end a bearing in which rotates a hollow sleeve. The centre line of this sleeve is adjusted to coincidence with the photometric axis of the bench used when making measurements.

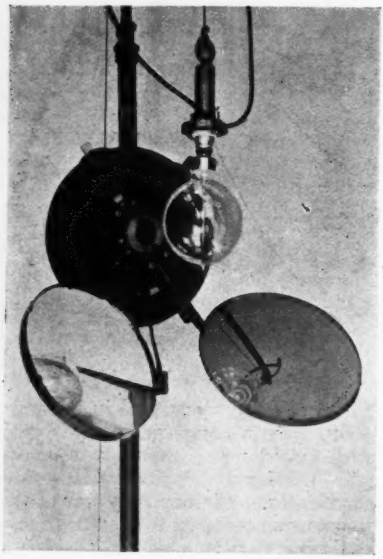


FIG. 6.—Central Axis and Mirrors on Lamp Stand.

The cap of the bearing carries another short vertical length of steel tube, in which is clamped a curved piece of steel cycle tubing supporting the lamp.

The height of the lamp is continuously adjustable by means of a winch

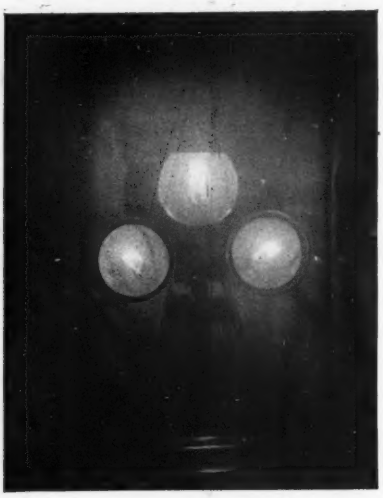


FIG. 7.—View of Lamp Stand with Arc Lamp Burning.

bolted to the lower portion of the stand ard, thus allowing the source of light to be brought exactly on the axis of the sleeve.

On this sleeve are two sheaves capable of rotation about the common centre line, and each carrying a curved arm of steel tube and a balance weight.

The angular positions of these arms are indicated by pointers attached to each, which move over a scale of degrees painted on the back of the large central disc.

In Fig. 5 an enclosed arc-lamp is seen in position, with oval mirrors in adjustment on the ends of the balanced arms, and in Fig. 6 a nearer view is given of the mirrors and central axis with a 200 candle-power metallic filament lamp in position for a determination of the reflection coefficient of the mirrors. The improvement in accuracy of observation due to the use of two mirrors symmetrically disposed about the lamp under test, instead of one, is very marked.

Fig. 7 is a view taken from the photometric bench with an arc lamp running, the screen for cutting off direct illumination of the photometer disc being removed.

The room is provided with ample facilities for the supply and measurement of continuous and alternating currents at constant pressure. Town gas can also be supplied and accurately measured when required.

It is safe to say that hardly any technical college or university has a photometric equipment for teaching or research superior to that now possessed by the Pender Electrical Laboratory.

The whole of the work has been done to the designs and drawings prepared under the direction of Dr. J. A. Fleming and the writer of this article, and embodies the experience of more than 15 years in this particular work.

Notes on Methods of Filament Manufacture.

By An Engineering Correspondent.

The chief problems in high efficiency filament manufacture are concerned with :—

1. The obtaining of a filament of sufficient mechanical strength.
2. The obtaining of higher specific resistance and low emissivity.

Filament materials are essentially thermally refractory, and, for the most part, they are difficult to handle from a mechanical point of view. The higher the specific resistance of the material of a filament, the less difficult it becomes to construct low candle-power high voltage lamps thereof, but, in seeking high electrical resistance, mechanical strength, refractibility, and emissivity must not be sacrificed. The data of Table I. show the specific resistance of various filament materials at present in use. It must be noted, however, that many metallic filaments are tubular in section, so that their specific resistance is apt to be over-estimated. (This tubular section may be the result of a manufacturing process in which a central supporting core is evaporated or burnt away after serving its temporary use ; *or* it may be that, in those filaments squirted as a paste, the outer layers dry first and the inner portions, contracting later and still adhering to the outer layers, leave a central space running throughout the filament.)

High resistance, low emissivity filaments have been sought after by the use in their construction of :—

(*a*) Two or more metals (sometimes alloyed, sometimes not) ;

(*b*) One or more metals in conjunction with one or more metallic or non-metallic salts ;

(*c*) One or more metallic salts alone or in admixture with certain refractory earths.

Two main classes of "compound" filament must, however, be distinguished, viz. (1) that in which the compounding is merely a means of obviating the manufacturing difficulties otherwise experienced in the production of a pure metallic filament, and (2) that in which the final filament

Table I.

Material.	Spec. Resistance at 0° C. Microhms per Cm. cube.	Resistance of 1 mm^2 wire per metre.
Carbon (unflashed) mean	1720 microhms	17·2 ohms.
Carbon (flashed) mean	1470	14·7
Platinum (annealed) : Matthiesen	8·98	0·08
Platinum (pure) : Dewar & Fleming	11·0	0·11
Osmium (mean)	47·3	0·47
Tantalum (mean)	37·0	0·37
Tungsten (mean)	28·2	0·28
Hard drawn ductile tungsten* (Coolidge)	5·50	0·055
ditto annealed	4·47	0·054

* Temperature coefficient of resistance=0·0051 per 1° C. (between 0° and 170° C.).

is also to have a complex composition. In the first class any permanent or stable formation of a compound is generally undesirable, whereas in the second class such stability is essential. In the "temporarily" compound filaments only such auxiliary materials as colloids or albumenoids or other ingredients capable of easy and complete elimination by heating are employed, whereas in "permanently" compound filaments only the most refractory materials, incapable of thermal or electrolytic dissociation, are used. Great difficulties are incidental to the choice of such materials, and it is owing to the doubtful permanency of their filaments that the latter have hardly left the laboratory stage though pregnant with great possibilities.

Purely transitory compounding processes are necessitated by the mechanically and thermally refractory nature of many high efficiency filament materials, and were any more convenient mode of procedure available they would be at once discarded. The chief of these temporary processes (corresponding precisely to the temporary framework of an engineering structure) involve :—

1. The use of pastes of finely divided metal with such organic materials as paraffin or carbon.
2. The use of colloidal or albumenoidal compounds of the metal.
3. The use of amalgams or alloys of the filament metal with other less refractory metals.
4. The use of certain salts (*e.g.* nickel tungstate) formed by the action of the acids of the refractory metals on less refractory metals.
5. The provision of mechanical support during attenuation.

1. The *Auer* process of preparing filaments from finely divided metal (so escaping the difficulty of preparing tantalum, tungsten, &c., in relatively large homogeneous masses suitable for drawing or rolling) consists in mixing the chemically precipitated or finely ground metal with paraffin, possibly adding carbon to the paste which, when well mixed, is squirted through a steel or diamond die. The thread is dried gently to prevent cracking and then heated strongly in vacuo or in an atmosphere aiding in the removal of the binder. Carbon is particularly difficult to remove completely; heating in H_2S is one of the best means of securing its eviction. Considerable shrinkage of the filaments occurs during their formation, but even so, and allowing for the "sintering" of the metallic particles, the material is inferior in density to the product of colloidal processes (though probably superior in uniformity).

The later *Arsem* process, very similar to the above, mixes WO_3 and fine graphite to a paste with a solution of ceresene, rosin, and gilsonite in benzole. The low temperature baking is conducted at 350° C., the reduction and sintering being secured by heating the filaments (packed in silica) to 1500° C.

2. The *colloidal* and *albumenoidal* processes (largely investigated by Kuzel) do not involve the initial preparation of the refractory metal in a finely divided state. Easily prepared and handled compounds of the metal are employed, their reduction to the metal being the last stage in the manufacture. By incandescing the filament in an atmosphere of hydrogen the elimination of every constituent except the metal itself (formed by reduction) is secured by a process at least as easy as the removal of carbon in the Auer process. The colloidal method of treatment is applicable to tantalum, osmium, tungsten, boron, and silicon among other metals.

3 and 4. The use of amalgams or alloys of refractory with less refractory metals may be regarded as a variation of method (1) using an inorganic binder. The "binder" metal is driven off from the squirted or drawn filament by thermal dissociation and direct evaporation. Tungsten, molybdenum, and boron may be thus treated by incorporation with a Hg-Cd alloy or, in the case of tungsten, with a Bi-Cd alloy. For molybdenum, copper has been employed. This method of manufacture is liable to leave a porous filament.

A process recently patented by the G. E. Co. (America) mixes powdered tungsten and cupric oxide with a

Cd-Bi-Hg amalgam. After squirting, the filament is baked at two heats: first the mercury distils off, the copper being reduced by the formation of cadmium oxide; then (*in vacuo*) the Cd, Bi, Cu and cadmium oxide successively evaporate in the order written, the remaining tungsten sintering when full heat is attained. The process is claimed to avoid disintegration by the formation of metallic globules of Cd and Bi during the early stages.

The use of such readily obtained salts as nickel tungstate possesses the further advantage (in this particular case) that a Ni-W alloy is very ductile and easily drawn. Nickel tungstate is reduced by heating in hydrogen: the resulting finely divided alloy is sintered electrically, drawn or rolled to wire, and the nickel then evaporated *in vacuo*. (The method is clearly an adaptation of the Wollaston process of drawing fine platinum wires.) The Ni-W alloy may contain from 5 per cent to 20 per cent nickel, tungsten being added to the tungstate in a metallic or colloidal form till the desired composition is reached: 10–12 per cent nickel appears to give the best results, 0·5–1·0 per cent iron, cobalt, or copper facilitating the formation of the alloy.

5. A tungsten rod, say, is encased in a shell of copper or nickel, drawn to the required diameter and mounted in its lamp bulb: the outer skin is then volatilized off, any deposits on the inside of the bulb being rinsed away by acid. This process, however, is apt to result in a final filament much weaker than is desirable for commercial purposes.

Until recently the only commercial lamp utilizing drawn pure metal was the tantalum. The method, which enables a continuous wire to be wound on a frame, the only junctions being at the leading in wires, has been claimed to give very substantial advantages as regards mechanical strength. The newly introduced Mazda lamp, however, is an example of the successful application of this method to tungsten filaments, and the use of drawn tungsten will undoubtedly prove an important development in the future manufacture of filaments.

The methods of preparing pure metallic filaments, which will probably persist, are: Drawing or rolling direct from a homogeneous mass of the metal—fortunately possible in the case of tungsten—or, failing this, the colloidal process and the use of organic binders.

Permanently "Compound" Filaments.—In the manufacture of these filaments the materials primarily chosen are generally those to be retained in the final product, temporary binders being rarely employed. By incorporating inert earths with a finely divided filament metal, the resulting filament has a porous structure as regards electrical continuity (*i.e.* of high specific resistance), but the spaces idle electrically are filled with a material of lumin ous and mechanical value.

The rare earths thus incorporated should not belong to the series of "second-class" conductors, for the latter are essentially electrolytic conductors, and subject to more or less rapid thermal and electrolytic dissociation when operated *in vacuo* (as is necessitated by the metallic components of the filament). For this reason the oxides of zirconium, yttrium, ytterbium, erbium, gallium and Di are unsuitable for such filaments: thorium oxide, if extremely pure, acts as a non-conductor, and may therefore be employed, up to 10 per cent being recommended.

A modification of this system mixes refractory metallic salts with a moderate percentage of a secondary conductor. Thus 10 per cent of a "rare earth" may be mixed with the silicide or boride of tantalum or tungsten, made into a paste with an organic binder, squirted, baked, and incandesced till uniform in character. The doubtful permanency of the "secondary" conductor employed and the necessity for an inorganic binder are disadvantages of the process. "Flashing" carbon on to such filaments leads to no good permanent result.

By using gelatinous salts of the rare earth metals in such filaments (*e.g.*, zirconium oxalate)—such salts being converted to oxide by heating—the use and the elimination of organic

binders are avoided, but the inherent defects of the filaments still exist.

By using the oxide, nitride, carbide, or silicide of a refractory filament metal, alone or together with similar salts, a more stable filament is obtained. A pure metallic filament may be first prepared and then burnt in a suitable residual gas to give the desired final composition, or a paste of the oxide, nitride, &c., may be squirted and baked in the ordinary way. Probably the latter system is the best, a greater uniformity of structure and a smoother filament surface being obtained.

Cored Filaments.—Under this heading come filaments made on the simplest possible principle of compounding—the consecutive addition of layer after layer of the same or different materials on to a suitable core which may or may not be ultimately removed. Attempts to raise the efficiency of carbon filaments by such means have hitherto proved worthless or, at the most, moderately successful. The use of allotropic forms of the same substance in the various layers has proved fairly successful (and is regularly employed in the "flashing" of carbon filaments).

The ease with which carbon filaments can now be prepared makes them excellent mandrils on which to deposit more refractory materials (electrolytically, thermally, mechanically, or as colloids). The permanent retention of such carbon cores is not permissible, but their complete removal, and without damage to the outer material, offers great practical difficulty.

Tantalum also provides comparatively easily manufactured mandrils on which may be deposited, for instance, colloidal tungsten (subsequent heating in hydrogen then yielding a shell of sintered tungsten round a tantalum core). The melting point of tantalum is too high to permit of the core being volatilized in such a case, while, on the other hand, it is sufficiently below that of tungsten to impose a serious limitation to the performance of the outer shell.

By an exact analogue of the "flashing" of carbon filaments an outer layer may be deposited on a carbon, tantalum, or tungsten core by incandescing the latter in the vapour of a volatile salt of the metal to be deposited (*e.g.*, osmium tetroxide or tungsten chloride): the "flashed" deposit being sintered together is not liable to the subsequent disintegration which proves the defect of many flashed carbon filaments.

Alloy Filaments.—Much has been hoped for and little attained from that class of filament which aims at the employment of alloys of various materials (mainly metallic). One point, however, is tolerably certain—only when a *definite compound* is formed by the alloying will the product offer higher (or even equal) refractibility than its components. Suitable alloys are difficult to prepare and often have insufficient stability. In this connexion the study of allotropic forms becomes of great importance. One form of a material is often much superior, as a filament material, to its allotropes (a notable instance being that of "metallized" carbon), but the use of allotropic forms is always subject to the danger of variation in the latter at the high working temperature required.

The formation of "solid solutions" of boron, silicon, or carbon in metallic filaments greatly affects the characteristics of the latter. There is little doubt that in such cases definite compounds are really formed so that the filaments are partially removed to a class already considered. Quite small percentages of added material greatly increase the specific resistance of the whole (to a figure which, in the case of tungsten, may be 5 or 10 times that of the pure metal): the surface of the filament is also affected, but not always favourably.

Conclusion.—The necessity of turning out a large number of lamps, of reasonable uniformity of characteristics and by commercially possible operations, has debarred from general use many lamps which proved of great promise in the laboratory stage. Yet as this brief review shows, very considerable additions to our knowledge in this respect have been made, and we may confidently look for still further developments in the near future.

R. E. N.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible or the opinions expressed by individual authors or speakers.

Recent Progress in Electric Lighting.

[Proceedings at a meeting of the Illuminating Engineering Society, held in the House of the Royal Society of Arts (London), on Friday, Dec. 9th, 1910.]

A MEETING of the Society was held as stated above, the PRESIDENT, PROF. S. P. THOMPSON, D.Sc. F.R.S., being in the chair. There was again an excellent attendance.

The minutes of the meeting having been taken as read, the PRESIDENT called upon the HON. SECRETARY to read out the names of applicants for membership received since the last meeting * (see p. 28), and also to read the names of those presented at the meeting on November 8th, who would now formally be declared members of the Society.

THE PRESIDENT then referred to the paper on **Recent Progress in Electric Lighting** about to be read by PROF. MARCHANT. Before calling upon him to do so, however, he had an important announcement to make. One department of lighting which was receiving the greatest attention at the present time was street lighting, and at the last meeting of the Institution of Electrical Engineers it had been suggested that some form of model specification was badly needed. This was naturally a matter of considerable interest to the Illuminating Engineering Society, and the Council had therefore decided to appoint a committee, with power to consult with others, to draw up, in a preliminary form, a **draft specification for street illumination,** and to take steps to learn the views of authorities in different quarters on this matter. The intention, he said, was to arrive at something which would make clear to borough surveyors and architects the proper basis of a street lighting specification. Such a model specification should be quite independent of any particular form of lighting, and would have no special reference to gas, electricity, acetylene, or any other illuminant. It would be concerned with those fundamental problems in street lighting which were common to all illuminants. Hitherto, with one or two notable exceptions, there had been no proper specifications for street lighting in general use, and he thought the Society had rightly taken the first opportunity of preparing the way by appointing a committee to deal with the matter.

The President then called upon PROF. E. W. MARCHANT to read his paper (which will be found *in extenso*, together with the discussion, on page 29), explaining that it was desired to abstain from introducing into the discussion controversial matters affecting the commercial interests of different systems of lighting—a condition which had been observed in the previous discussion on gas lighting.

Subsequently PROF. G. W. O. HOWE presented a communication on **The Blackening of Tungsten Lamps.** An interesting discussion then took place in which MR. A. P. TROTTER, MR. HAYDN T. HARRISON, MR. A. H. SEABROOK, MR. H. D. WILKINSON, MR.

* *Illum. Eng.*, Lond., Dec., 1910, p. 713.

J. Eck, Prof. J. T. Morris, Mr. L. Gaster, Mr. P. J. Waldram, Mr. T. E. Ritchie, and Mr. J. S. Dow participated.

In conclusion The President called on Prof. Marchant to reply, and closed the proceedings with the announcement of the date of the **next meeting**, which was to take place in the same room on **Monday, January 16th, 1911,** at 8 p.m. On this occasion the subject of Library Illumination would be dealt with, and the Library Association had kindly consented to co-operate with the Society on this occasion in order to render the discussion representative of the views of those concerned with all aspects of the subject.

The meeting then terminated, and most of those present adjourned to the library, where tea and coffee were provided.

NEW MEMBERS OF THE SOCIETY.

The names of the applicants for membership, read out at the previous meeting on November 8th, were formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on December 9th :—

Members.

Addicks, W. R.	President of the United Electric Light & Power Co., New York City, and Vice-President of the Consolidated Gas Co. of New York, 4, Irving Place, New York, U.S.A.
Crow, H. W.	Tar Distiller, 18, Northumberland Avenue, South Wanstead, Essex.
Cunnington, W.	13, The Chase, Clapham Common, London, S.W.
Hind, W. S.	Sales Dept. of Marylebone Municipal Electric Supply, Westholme, Rutland Road, Harrow, Middlesex.
Holmes, H. H.	Sales Manager, Marylebone Municipal Electric Supply, 31, Hampton Road, Forest Gate, Essex.
Reilly, E. P.	Civil Engineer, Chief Engineer and Manager of the Cape Town and District Gas Company, 32, Victoria Street, London, S.W.
Stephens, J. N.	Electrical Engineer, Lamp Dept., British Thomson Houston Co., 40, Prince's Square, Hyde Park, London, W.
Walters, H.	Engineer to the G.P.O., 9a, King Edward Street, London, E.C.

* *Illum. Eng.*, Lond., Dec., 1910, p. 713.

Official Notice of Next Meeting.

The next meeting of the Illuminating Engineering Society will be held at the House of the Royal Society of Arts (John Street, Adelphi, London), on **Monday, January 16th, 1910** at 8 p.m., when a discussion on the subject of **Library Lighting** will take place.

The Library Association is co-operating with the Illuminating Engineering Society in connexion with this discussion and the meeting will be attended by members of both bodies. The discussion will be opened from the librarian's standpoint by **Mr. J. Duff Brown** (Islington Public Libraries) and **Mr. S. L. Jast** (Croydon Public Libraries), and it is hoped that the standpoint of the architect and the illuminating engineer will also be well represented.

The Chair will be taken by **The President, Prof. S. P. Thompson, D.Sc., F.R.S.**

Applications for tickets should be made to the Hon. Secretary, Mr. L. Gaster, 32, Victoria Street, London, S.W.

Recent Progress in Electric Lighting.

By **E. W. Marchant**, D.Sc., Professor of Electrical Engineering at Liverpool University.

(Paper read at a Meeting of the Illuminating Engineering Society held in the House of the Royal Society of Arts (London), on Friday, December 9th, 1910.)

Recent Developments in Electric Lighting.

It would perhaps be more accurate to describe this paper as one which attempts to give some account of recent developments in electric lamps rather than one on recent developments in electric lighting. If the paper contains little that is new it is because the subject has been dealt with so exhaustively by Mr. Gaster in his Cantor Lectures last year, and in the *Journal* of the Illuminating Engineering Society. It is always the case with papers of this kind, that the discussion produces far more useful information than the paper itself contains, and it is in this hope that it is presented for your consideration.

Incandescent Lamps.

The most remarkable development within recent times is the production of an incandescent lamp with an efficiency approximating to 1 c.-p. per watt. The best known of these lamps are of two kinds, one made with tantalum as the material for the filament and the other with tungsten. There are a great number of lamps under a great variety of different names using tungsten, and the difference between the lamps is largely due to the differences in the processes of manufacture adopted. The most recent development in the construction of tungsten lamps is in the use of wire-drawn filaments.* Lamps made in this way are now being produced in large numbers, and it is claimed that these filaments are mechanically stronger than those in which the thread is obtained by deposition of the metal, or by some process equivalent to it. One of the chief drawbacks to the use of tungsten filaments has been their great fragility, but in this connexion it should be noticed that the filaments are not very fragile, except when cold; metal filament lamps will stand a great deal of vibration when they are lit, whereas the same lamps when cold are soon broken under similar conditions.

Another point connected with the life of these lamps is the effect of switching off and on. In order to test a statement that has been frequently made as to the bad effect of switching off and on, a series of tests are being carried out in the Electrical Engineering Laboratories at Liverpool, in which the lamps are switched off for 10 seconds and then switched on again, the process being repeated at intervals of one minute. Although these tests are not complete, the results, as far as they go, have been interesting.

In all, twenty lamps, which have been supplied by several makers, are being subjected to this test. The lamps were divided into two groups, and each one was adjusted to have an initial efficiency approximating to 1.4 watts per candle-power; this adjustment was effected by introducing resistance into the circuit of each individual lamp. One set of 10 lamps was connected in circuit with an automatic switch driven by a small fan motor at such a speed that a cam switched on the current for 50 seconds and switched it off for 10 seconds. The

* L. Gaster, Cantor Lecture, 1909.

reason for this choice of time was that it appeared that 10 seconds was long enough to allow the filament to become practically cold, and thus to give the maximum contraction and expansion of the thread. As far as the experiments have gone the effect of switching does not appear to be serious; the lamps that have been burning continuously have given out to the same extent as those that have been subjected to the continuous switching off and on.

The test cannot, of course, be regarded as exhaustive, on account of the comparatively small number of lamps used; and the detailed results obtained will be published after the tests are complete. The number of switchings to which, so far, each lamp has been subjected is 25,000 approximately, and all the lamps except two are still burning.

I may here mention the well-known phenomenon of the remarkably long life (both actual and effective) of metallic filament lamps, the life being defined as the time which elapses before the candle-power falls to 80 per cent of its initial value. Two lamps bought in the ordinary way have been under continuous observation in my laboratories for the last few months. They have been connected to the town mains, without a regulator, and have been tested for candle-power and current consumption at their rated voltage. The curves showing variation in candle-power and watts per c.-p. are given in Fig. 1. The initial efficiency was about 1·2 watts per mean horizontal candle-power for one lamp, and slightly higher for the other.

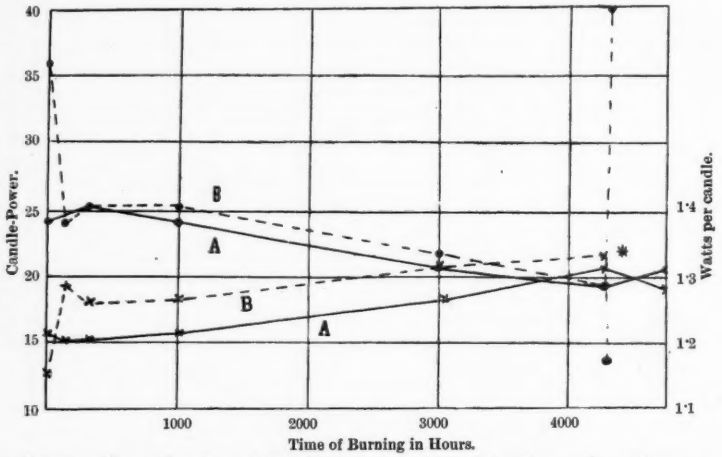


FIG. 1.—Curves showing relation between (1) Time of burning and candle-power (2) Time of burning and watts per candle. Two Tungsten lamps are tested, the corresponding curves being marked A and B respectively, and indicated by full and dotted lines.

1. ● ● ● indicates curve connecting time and candle-power (upper).
2. × × × „ „ „ „ and watts per c.-p. (lower).
* indicates two filaments partially short-circuited.

No doubt many other examples of long burning lamps can be given by others using them commercially. Some very interesting life tests of metal filament lamps have recently been made by F. Lavender.* From the practical point of view the time of burning before the filament breaks is more important than the life of the lamp, as defined by reduction in candle-power. As Dr. Sumpner said in a discussion on this subject, the rule for a metallic filament lamp is to burn it until it breaks; for

* *Proc. Inst. Elec. Engineers*, vol. xliv., p. 181.

a carbon lamp to throw it out when it burns red.

Fig. 2 is the reproduction of a curve which has been supplied to me by the courtesy of the British Thomson Houston Co., giving the relation between the effective life of tungsten filament lamps (as defined on the 80 per cent of initial candle-power basis) and initial watts per candle-power. The effective life is found by them to be roughly proportional to the 3·65th power of the initial watts per candle-power, a law which corresponds with that found for carbon filament lamps.

Fig. 3 shows graphically the well-known result that the change in candle power is much smaller for a given percentage change in voltage

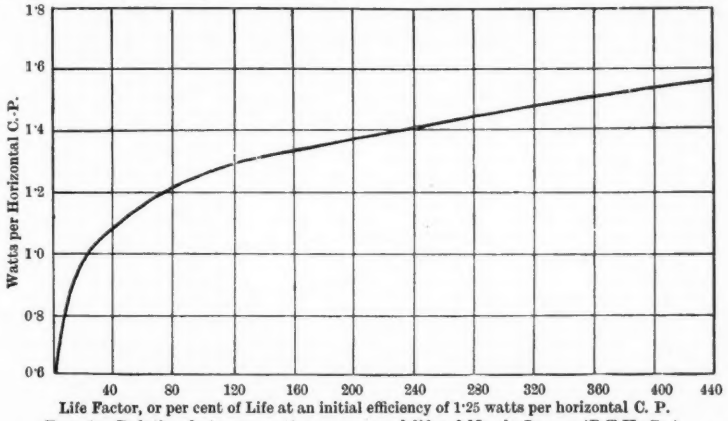


FIG. 2.—Relation between watts per c.-p. and life of Mazda Lamps (B.T.H. Co.).

for tungsten filament lamps than it is for carbon filaments. This result is important from the point of view of light standards. A metal filament lamp is a more suitable secondary standard for candle-power measurements than one with a carbon filament.

EFFECT OF VIBRATION.

It is very difficult to get definite information as to the effect of vibration on the life of metal filament lamps. There seems to be little doubt that vibration is injurious, though there is reason to think that its effect has been greatly exaggerated.

A large number of lamps in my laboratory are hung from a light roof supported on an upright girder on which counter-shafting is carried. These lamps have now been in place for over a year, and are lit on the average during the winter for from two to three hours every evening; so far, not a single lamp has given way. It is probable that metal filament lamps are much more injuriously affected by the sudden shocks they receive when their globes are being cleaned than by any ordinary vibration to which they may be subjected. At the same time, vibration must be injurious in certain cases. In a great number of lamps which have come under my observation the filament, when it has become weakened, tends to fuse up, *i.e.*, two threads fuse together and short-circuit part of the filament. The candle-power and efficiency of the lamp rise temporarily, though this phenomenon is a nearly certain prelude to a rapidly approaching end. This effect is clearly shown in the curves for lamp (B) Fig. 1, and also to a small extent for (A). In most cases of lamps burning continuously the short-circuiting of part of the filament has occurred before the lamp has given way, and it is obvious that this tendency must be greatly assisted by vibration.

One may sum up the position as far as metallic filament lamps are concerned by saying that at present there is no difficulty in obtaining a 230 volt metal filament lamp of about 25 candle-

power which will give one horizontal candle-power for 1·2 watts, and will burn near this efficiency for over 1,000 hours; probably for a much longer period, under ordinary conditions.

As far as improving the illumination given by lamps is concerned, as much may usually be done by using suitable shades as by improving the efficiency of the lamp. By using suitable reflecting shades a great increase in illumination may be effected by reflecting light (which would otherwise be wasted) in the direction in which it is wanted.

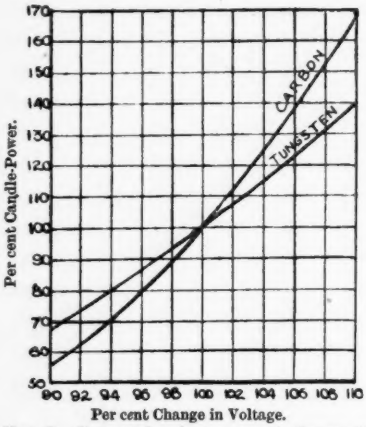


FIG. 3.—Curves showing per cent change in c.-p. of Mazda and carbon lamps due to per cent change in voltage.

As examples of ways in which metal filament lamps may be used to give a uniform shadowless illumination, I may mention two cases. In a small drawing office excellent results have been obtained by using metal filament lamps uniformly spaced at intervals of about three feet just below the ceiling. The room was about 12 ft. high, and 18 lamps were used of about 20 horizontal candle-power each. The total area of the room was 600 square feet, and the current consumption 0·8 watt per square foot. The average illumination on a drawing board over the central area, 3 ft. above the ground, was 3·5 foot candles, and this varied from 3·0 to 3·9 foot candles. Making suitable allowance for the ratio between mean spherical and mean horizontal candle-power, this gives an illumination efficiency of about 60 per cent.* The illumination was practically shadowless; any one leaning over a board could draw quite well, and the general effect was better than that obtained with inverted arcs, with the additional advantage that the illumination was not so directly dependent on the state of the ceiling. An illumination chart for this room is shown in Fig. 4.

In this connexion it may be interesting to compare the amount of light used, as contrasted with that employed when the well-known rule of one 16 c.-p. lamp per 100 square foot was used. The total candle-power used in the above example is four times as great as with the old rule, and the illumination is of course increased in a corresponding degree.

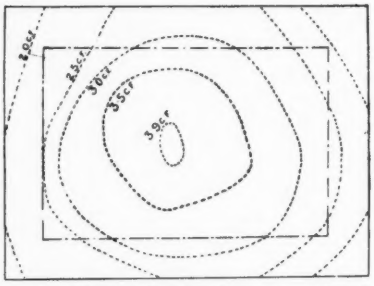


FIG. 4.—Illumination chart for a room 21 ft. by 27 ft., illuminated by eighteen 20 c.-p. lamps uniformly distributed over the ceiling.

A method similar to the one just described, which has lately come much into vogue in America, is the use of groups of tungsten lamps carried in inverted shades containing silvered reflectors. In one instance recently described,† where lighting was effected in this way, the illumination was estimated at 2·3 foot candles, 2 ft. above the floor. The power consumption was 0·83 watt per square foot. In modern systems of lighting it is becoming increasingly recognized that it is necessary to screen the direct image of the lamp filament from the

* The efficiency is here defined as the ratio between the total luminous flux received by a horizontal area to the total flux of light emitted by the lamp. This quantity may be greater than unity if the area considered is covered with non-absorbent material.

† *Electrical World*, vol. lxiv., p. 620.

eye. The intrinsic brilliancy of such a filament is very high, and the image formed on the retina is now recognized as producing an unduly severe stimulus, which, if often repeated, may prove injurious. This point is now so well known that it is unnecessary to labour it further. Before leaving the subject of incandescent lamps it may be of interest to make some remarks on the character of the light that is emitted from them. The spectrum obtained corresponds with the spectrum given by an incandescent body, *i.e.*, it is a simple band spectrum. As far as my own observations have gone, there is no evidence of selective emission, and the increase in efficiency of metal filament lamps may be said to be entirely due to the higher temperature at which the lamp filament runs. The wave-length of maximum emission intensity corresponds fairly closely with Wien's law for the radiation emitted by a black body. (It may be of interest to note here how nearly the temperature of maximum emission intensity for the yellow line (D) or centre of the *visible* spectrum (about 6200 deg. C. corresponds with the estimated temperature of the sun.)

The nearer we can approach the temperature of the sun with artificial sources of light the more nearly will an illumination be obtained which corresponds in all regards with sunlight.

It is of course possible by a suitable admixture of colours to obtain a colour which gives to the eye the appearance of white light. If one uses the method of colour-mixing adopted in the three-colour process, one can obtain a very close resemblance. This method is physically possible but in practice bound to be inefficient. The number of distinct tints that have now been stated by competent observers to be distinguishable from one another is 160,* and at present no artificial light enables us to obtain exact matches in colour for all these exceedingly small variations in tint. It will be a long time before the painter is prepared to trust to an artificial light for exact colour reproduction.

* Külpe, Outline of Psychology, Wurzburg.

Arc Lamps.

The most notable advance in arc lighting is the flame arc, but these lamps have been used so extensively for a number of years that the flame arc itself is far from being a recent development. With one exception these lamps all give off a good deal of fume and vapour (which make them unsuitable for indoor lighting), and the developments have therefore been mainly in the direction of making them suitable for street lighting.

The paper dealing with the subject of street lighting which was read at the Institution of Electrical Engineers* by Mr. Haydn Harrison only a few days ago has dealt with this subject in great detail, and it is my intention in this paper to lay stress on only two points :—

1. The improvements made in the distribution of light so as to give more uniform illumination over a large area.
2. The actual efficiency or flux of light emitted per watt consumed in a modern lamp.

(1) The attempt to obtain more uniform illumination on the surface has been made in two ways. *First* by using vertical carbons instead of V carbons, as in the earlier form of flame lamps. As has been pointed out by many people, the candle-power curve required to give uniform horizontal illumination is much more closely approached by the polar curve of light distribution given by a vertical carbon lamp than by any other form.

The distribution curve given in Fig. 5 for a Crompton Blondel lamp shows what may be done in this direction. The horizontal illumination curve has also been drawn for this lamp, and it will be seen that it is possible to get a diversity co-efficient of only four along the line connecting two lamps, when the lamps are placed 140 ft. apart, the lamps being 25 ft. above ground.

This is a result as good as most illuminating engineers expect to obtain,

* *Proc. Inst. Elec. Eng.*, Nov. 25th, 1910.

and a result far better than is found in most streets at the present day.

Among other lamps of this type is the Jandus enclosed flame lamp, curves for which were given by J. T. Morris* and further results for which are given in Mr. Haydn Harrison's paper.† The results calculated from these distribution curves show that it is possible with lamps spaced 200 feet apart and 20 feet high to obtain a diversity co-efficient as low as 3·5 along a line connecting two lamps. This is a lower value of this co-efficient than has been obtained in practice, as far as I am aware. I have made a number of tests of street lighting in Liverpool where "Excello" lamps are used, and have found with lamps on poles about 25 feet high, and spaced 150 feet apart, that the diversity co-efficient is about 20. It is, however, difficult always to determine this quantity exactly, on account of light reflected from windows and light from side streets.

The *second* method which has been adopted with a view to improving the light radiation from V carbon lamps is by the use of special globes. The most notable example of this is the use of the dioptric globe in connexion with the "Excello" lamp. I have not, unfortunately, been able to make any tests on this lamp myself, but I have been furnished with a number of test results, some of which are, I think, of value and importance.

The curve of light distribution from this lamp, fitted with its special globe, has been published so recently that it need not be repeated here, and the enormous advantage in the direction of uniform illumination obtained by using these dioptric globes is sufficiently apparent from the paper already quoted.

2. Actual efficiency of modern arc lamps as measured by the flux of light per watt consumed.

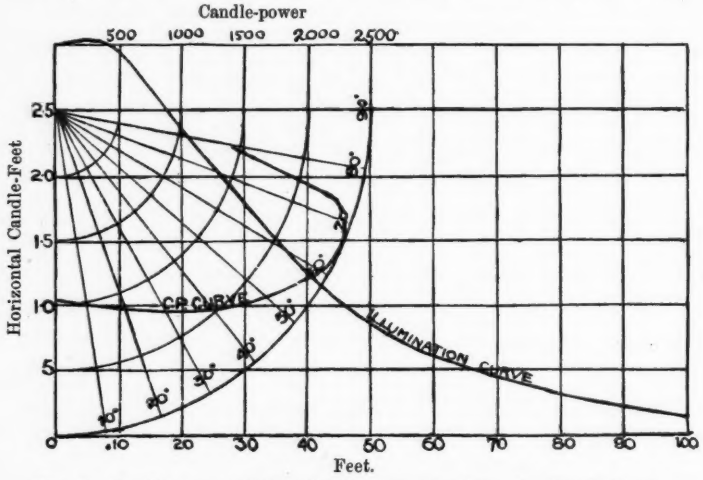


FIG. 5.—Candle-power and Illumination Curves for Crompton-Blondel Lamp. (Lamp 22 feet above ground.)

It is necessary to distinguish clearly between the two factors, light distribution and light efficiency. They are obviously quite distinct and different. However great the improvement in distribution of the light that can be effected by altering the globe, this improvement can never go beyond the point at which the whole of the light produced is used in the most economical way. If a further increase in illumination is required for a given expenditure of power, it must be obtained by increasing the total flux

* *Illum. Eng.*, vol. i., p. 717.

† 'Street-Lighting,' *Proc. Inst. Elec. Eng.*, Nov. 1910, curve 2.

of light from the source. There has recently been constructed in my laboratory a globe photometer, the details of the construction of which are given in the Appendix, and with this photometer a number of comparative tests of mean hemispherical candle-power have been made on lamps working under different conditions. The results of these tests are given in the accompanying table. The globe was standardized by metal filament lamps, and the standard of comparison was a small metal filament standard lamp.

Type of Lamp and Globe.	Volts.	Current.	M.H.S.C.P.	C.-P. per watt.
"Crompton Blondel" slightly opalescent globe	40 47·5	7 8·3	1040 2320	3·72 5·88
"Excello" clear inner globe opal outer globe	49·5	13	3520	5·45
"Excello" clear inner globe slightly opalescent outer globe	52·3	12·2	4360	6·85
"Reaun" Singly enclosed arc lamp	85	6·4	836	1·53
"Reaun" Midget Lamp	77	3·3	250	·98

The tests have all been made with the globes in position, and the results agree fairly closely with figures that have been published elsewhere. The light given by the open flame arc tested is white in colour and the globe is slightly obscured, the light from the enclosed flame lamp is yellow, and that from the singly enclosed arc lamp of the well-known blue colour.

Yellow light is a much better one for penetrating fog than one containing fewer red rays, though there appears to have been some recrudescence of opinion in favour of white light for outdoor lighting, and quite a number of modern flame lamps are made to give a white light, or pseudo white light. The question of the colour of the light is not one of great importance for street lighting, except as regards fog penetration, but when it is important that colours should be distinguishable without undue alteration, the use of these lamps (especially the yellow flame lamps) becomes practically impossible.

Inverted arcs for interior lighting appear to be much less used than formerly, and those who have had trial of metal filament lamps for lighting drawing offices and other similar places have no great difficulty in understanding the reason for this. The best arc lamp cannot compare with metal filament lamps as regards steadiness of burning; and most arcs, from the flickering character of the light they emit, even when burning under the most favourable conditions, are quite unsuitable for drawing office lighting. Another point which has led to their abandonment for interior lighting is the labour involved in renewing carbons. When a large number of lamps are used, as for street lighting, this difficulty is not serious, since a special staff is employed to carry out the necessary renewal of carbons. Further, with inverted arcs there is not a great gain in efficiency of lighting, as compared with direct (*i.e.*, non-reflector) metal filament lamps. The main field of utility for arc lamps is street lighting, and it is for this purpose that the greatest progress has been made in their design. It may be desirable to mention the magnetite* lamp which is used so largely in America, and it is to be hoped that some further figures with regard to its efficiency may be forthcoming in the discussion.

Vapour Lamps.

The production of light from an incandescent vapour is a method of lighting which has long been familiar, though the only practical examples of it are the mercury vapour lamp and the Moore tube. The two forms of mercury vapour lamp which are being manufactured at present are the Quartzlite lamp, and the Silica lamp. The drawback to the early forms of lamp, in which glass was used, was that any excess in pressure or any

* *Electrician*, vol. lxiv. p. 51.

defect due to the mercury tube not emptying properly when the light was first struck, led to the glass fusing. The modern lamps are much more robust, and I have had a Quartzlite lamp* burning in my laboratory for several hundred hours without giving any trouble. The tube in which the mercury and the mercury vapour are contained are, of course, of quartz. The main characteristic of this lamp is that it produces a large amount of ultra-violet light, to which quartz is transparent, and which is screened off from the exterior by a heavy lead glass cover. If the lamp is left burning without this cover for a few minutes the smell

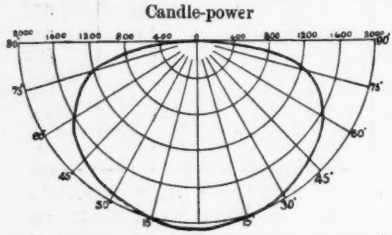


FIG. 6.—Polar Curve of Light Distribution for "Silica" Mercury Vapour Lamp, with Reflector.

of ozone produced is very strong. It is a matter for discussion whether this type of light containing these very strong lines only in the spectrum will not ultimately prove injurious to the sight of those who are obliged to work in it. A *priori* it would seem to be bound to produce a fatigue of those parts of the retina which respond to the impulses given by the particular rays which the lamp emits. It has, however, been used quite extensively for drawing office lighting, and appears to serve admirably for this purpose.

A lamp of this type has recently undergone test in my laboratory, with the result that the efficiency worked out at 1·73 c.-p. (mean hemispherical) per watt. The lamp consumed 688 watts at 230 volts, and gave a mean hemispherical candle-power of 1190.

The second lamp of this class is the Silica lamp, a development of the original Cooper Hewitt lamp. This lamp is similar to the Quartzlite lamp, differing from it chiefly in the fact that the tube in which the light is produced is made with silica instead of quartz. The distribution of candle-power from this lamp is shown in Fig. 6, and it will be seen that it resembles that for a flame V carbon lamp very closely. The chief drawback to mercury vapour lamps is the remarkable colour effects they give with coloured objects. In this regard reference may be made to the recent work of H. E. Ives* which has been very briefly mentioned in *The Illuminating Engineer*. The interesting result was found that the Welsbach gas mantle provided a very satisfactory complement to the light produced by the mercury vapour lamp when the resultant light of each source was in the ratio of 1 c.-p. mercury vapour to ·57 c.-p. of Welsbach gas mantle, the mantle having ¾ per cent cerium.

The mixing of the mercury vapour light with that of the light from tungsten lamps has been tried at Liverpool with quite satisfactory results. The ratio between the amount of light required to produce complete mixing being very easily found by aid of the globe photometer and two pieces of milk glass, one piece illuminated by a beam of daylight from the outside and the other by the light diffused on the surface of the globe by the two sources of light inside the globe. This method is of course not so exact as the colorimeter of Ives, but gives quite satisfactory results. The relative figures given by Ives are 1 c-p. mercury to ·54 c.-p. tungsten lamp light. Another suggestion which has never come under my personal observation is to use Neon tubes† combined with mercury vapour tubes. Whatever method is used for obtaining an approximately white light, the result can never be entirely satisfactory for all colours, unless the spectrum of the added light is an exact contrast to the spectrum of the mercury vapour lamp. The bands or lines of the spectrum with the newer mercury vapour lamps are slightly wider than they are with

* *Illum. Eng.*, vol. i., p. 81, vol. ii, p. 170.

* *Elec. World*, vol. liv., No. 13.

† Oester.-Ungar. *Install.* July 3rd, 1909.

the older type of lamp (with a glass containing tube) but their spectrum is very far from being a band spectrum. The Moore tube has not been used very largely in this country for lighting purposes, and results of tests made on this method of illumination have been described so recently* that it is not necessary to refer to them here.

In conclusion, I must express my thanks to the following firms for having sent me samples of their lamps to test :—The British Thomson Houston Co., Brush Electrical Engineering Co., Messrs. Crompton & Co., Messrs. G. M. Boddy & Co., Messrs. Edison & Swan, and The Reason Manufacturing Co. I must also express my thanks to Mr. W. Parry for his assistance in making tests and in working out results.

APPENDIX.

Globe Photometer.

The photograph in Fig. 7 shows a globe photometer which has recently been constructed in the Electrical Engineering Department of the University of Liverpool. It is 5 ft. 3 in. internal diameter. It is built in two halves, each supported on an angle iron base fitted with rollers arranged so as to enable the two halves of the globe to be separated. The main structure of the globe consists of 46 $\frac{5}{8}$ in. T-iron, each length of which was bent cold over a wheel to the right diameter. These ribs form "meridians" for supporting the asbestos millboard of which the sphere is constructed. They are carried at the base by a piece of sheet iron 14 in. in diameter which rests on a wooden support. The ends of the T iron are brought up to the sheet iron and bolted to the edge. At the top a wrought iron ring of 12 in. internal diameter, $\frac{1}{2}$ in. thick and 2 in. wide, carries the other ends of the meridional ribs. The ribs are kept spaced by $\frac{1}{4}$ in. iron rods screwed at the ends and attached by nuts to the T iron ribs. Two rods between each piece of T iron are sufficient. By this means a perfectly rigid globular structure was obtained, and this was stayed from the base by light bars. (In building up the sphere the top ring was continuous, and was only cut when the ribs had all been fixed in position.) The edges of the two hemispheres are formed of two pieces of $\frac{1}{2}$ in. angle bent to the right shape and supported in the same way as the ribs. The whole interior is lined with asbestos mill board $\frac{1}{4}$ in. thick attached to the ribs by binding wire. The mill board was first cut in meridional shaped

Fig. 7.—Ulbricht Globe Photometer.

sectors soaked with water and then wired in position, interstices being filled with a compound of glue and asbestos. After the surface had been smoothed and all interstices and cracks filled with this compound, the whole interior surface received about eight coats of white paint. The measurements are made by a piece of milk glass about 2 in. in diameter supported in a sliding tube so that the position of the glass may be made to coincide as nearly as possible with the surface of the sphere. A screen of white asbestos mill board painted with several coats of white paint is carried by a brass rod, and is so placed as to screen all direct light from a lamp placed at the top of the sphere, and prevent it from falling on the milk glass. Consider-

* *Illum. Eng.*, Oct., 1910, Fleming vol. i. p. 19.

able care has to be exercised in choosing a colour of milk glass which will not seriously alter the apparent colour of the light that is being examined. Most milk glass appears to have a pink tinge as compared with the white surface of the sphere. The mean spherical candle-power of a lamp is found by measuring the illumination of the milk glass by a photometer in the usual way.

I must express my indebtedness to Mr. E. H. Morgan for many suggestions in connexion with the design of this photometer.

Note on the Blackening of Tungsten Lamps.

By Prof. G. W. O. Howe, M.Sc. Whit.Sch. M.I.E.E.

(Presented at the Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts (John Street, Adelphi, London) on Friday, December 9th, 1910, at 8 p.m.)

Three years ago a number of Osram lamps were installed in the Lecture Theatre of the Electrical Engineering Department of the Central Technical College. The supply pressure being 200 volts, the lamps were connected two in series. Three pairs consisted of 110 watt lamps. One of these failed during last winter, the filament breaking away from the leading-in wire. It was repeatedly mended by bringing the end of the filament into contact with the end of the leading-in wire, but the contact was always loose and uncertain. The lamps had been running about 1,500 hours before this one failed. Although all the six have since been replaced, three of them are still unbroken. At their normal voltage they take 100 watts and give 36 mean horizontal candle-power after a life of well over 1,500 hours. Their specific consumption is therefore 2·8 watts per candle.

Before the lamps had been running long it was noticed that some of them had blackened considerably, and, on examination, it was found that the upper part of the bulb, *i.e.*, the part near the cap, was heavily coated with a brilliant copper-coloured deposit.

When recently examining this deposit a very peculiar thing was noticed. A relatively clear unblackened pattern had been made on the globe, indicating that the blackening had been caused by particles projected from a single point. By careful examination of the shadow it can be seen that the point from which this bombardment proceeds is the joint where the filament is connected to one of the leading-in wires. This is the point at which two of the three broken lamps have given way. As the accompanying photographs show, the pattern is sharply defined, every little detail in the glass stem and wire supports being faithfully reproduced in the shadowgraph on the bulb.

The brilliant copper colouring near the cap is evidently due to the "blackening" being so thick that it acts as a mirror and reflects nearly all the external light falling upon it. By transmitted light it appears green. Its thickness is greater on the side nearer the joint from which it proceeds, the density of the deposit being probably inversely proportional to the square of the distance from this point.

It is not due entirely, if at all, to any arcing which may have taken place after breakage, for it is plainly evident in all the unbroken 110 watt lamps.

Upon closer examination it will be seen that there are two shadowgraphs side by side in each lamp, the foci being the two joints between filament and leading-in wires.

They are both plainly visible in some of the lamps, but in one lamp I have not found any trace of a second shadowgraph. It is difficult to say whether both the positive and the negative joints are effective in blackening as the lamps had unfortunately been removed once or twice for cleaning purposes and may have been replaced

with their polarities reversed. In the lamp which shows only one shadow-graph the focus is the negative leading-in wire, from which it looks as if the negative joint is either the only or the principal source.

There is no apparent difference between the two lamps constituting a pair for series burning; this was specially noted because the negative side of the system is earthed.

In one lamp there is a third shadow-graph proceeding from the joint at the end of the first loop on one side.

Pear-shaped Osram lamps of smaller candle-power which were installed at the same time are not so blackened and show no sign of a pattern.

From the sharpness of the pattern it is evident that the projected material comes neither from the filament nor from the leading wire, but from the point where these are joined together. A discharge apparently occurs in the vacuum between the two joints which are about 1 cm. apart, and have a potential difference of 100 volts. The filament near these joints is incandescent and has the same potential difference,

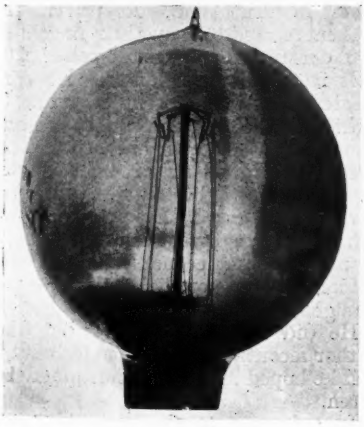


FIG. 1.

while the joints themselves are relatively cool.

The question which naturally arises is, Of what is the deposit composed? Mr. Robertson of the Central Technical College has kindly examined it *and finds it to consist mainly, if not entirely, of copper.*

The leading-in wires in both the large and small lamps are found on

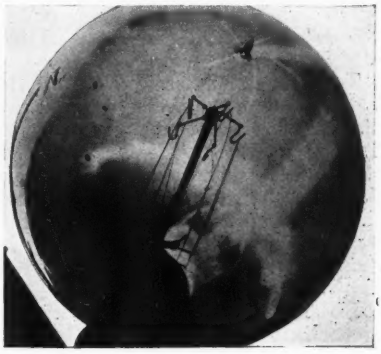


FIG. 2.

analysis to consist of an alloy containing a large proportion of copper.

Now the joints are made not by cementing, but simply by arcing between the filament and the leading-in wire in accordance with Patent No. 27714 of 1904, and the makers have informed me that the method is the same for both small and large lamps, and that it has not been changed since these lamps were made. If this is so the copper particles which seem to be torn off the cathode and shot radially outwards must proceed from the leading-in wire, their liberation being favoured by the heating of the end of the wire by conduction from the filament.

The small lamps must differ in some way from these large ones, or we should get the same phenomenon in them. It appears probable that some solder or cement was used in making the joints in the large lamps and that the copper in this solder or cement has been torn out by the electrical stress.

If the methods or materials of manufacture have not been altered since these lamps were made, it is evidently possible for the makers, by excluding copper from the joints, to reduce the blacken-

ing to a large extent, and at the same time reduce the probability of breakage. Perhaps it should be mentioned that all the lamps under discussion are of German manufacture.

NOTE.—Since writing this paper my attention has been drawn to an interesting lecture delivered by Prof. Fleming at the Royal Institution in 1890, at which a similar copper deposit was shown in a carbon filament lamp in which the joints had been made by means of copper clips.

Discussion.

THE PRESIDENT said that at the last meeting of the Society there was a discussion upon recent progress in gas lighting in which there was no intrusion of conflicting interests. He hoped, in the same way, there would be no need that evening to enter upon unnecessarily disturbing topics, but that the speakers would confine themselves to a discussion of the subject in hand.

He had been interested in the appendix to the paper and Dr. Marchant's particular way of constructing an Ulbricht globe. Not many months ago Dr. Sumpner had shown how closely it was possible to approximate to accurate results by merely using a rectangular box, lined with white, for the very same purpose. He did not know whether any one had yet followed Dr. Sumpner's suggestion and constructed such a box photometer. If so, perhaps they would hear whether it worked as well in practice as a spherical one.

Whilst he did not intend to take an active part in the discussion there was one point to which he would like to refer, and that was the mention in the paper as to how nearly the temperature of the maximum emission intensity for the yellow line D or centre of the visible spectrum (about 6,200 degrees C) corresponds with the estimated temperature of the sun. On this he would remark that the yellow line D might correspond with the dominant wavelength of the light from the sun as we see it in London, or even out of London and at sea level; but the real colour of sunlight was never seen unless we went to heights of three or four miles. The atmosphere even at that height absorbs a very large amount of light from the blue and violet and ultra-violet end of the spectrum, and real sunlight is a great deal bluer than what we are accustomed to call white light, so that there must be some discrepancy between the temperature of the yellow line D and the mean temperature of the sun. Sir Norman Lockyer once said that the sun was actually a relatively blue star and that our own atmosphere tempered it down so that it did not look blue.

MR. A. P. TROTTER thought the rate of progress as regards the size of light units was a little too fast: at any rate, it was for him personally. He had 205 volts in his house, and consequently could not get anything less than a 20 candle-power lamp. He preferred to arrange his lamps so that there was no light at all coming direct to his eyes, but with a 20 candle-power lamp he got about 10 ft. candles, which was too much. In his office he had a carbon lamp and preferred it very much to a metal filament lamp. At present the makers seemed to snap their fingers at the demand for 8 candle-power 200 volt metal filament lamps. He contrasted the size of present day units of light with the old-fashioned days when one went to bed with one candle, and even ladies found six or eight candles gave sufficient light to dress and read with. It showed that progress was bringing about a great change not only in methods and economy but in the actual amount of light that people thought they wanted.

He did not quite grasp what the author meant by "luminous efficiency," and he hoped an explanation would be given.

In reference to the author's statement regarding the reproduction of artificial daylight, Mr. Trotter recalled that in his own paper before the Institution of Electrical Engineers in 1894 he threw out the suggestion that this was possible. He had made a few experiments but had never seen it

attempted until recently, when he was in the photometric laboratory of Mr. Cooper, of the Brighton and South Coast Railway. That gentleman used an acetylene standard of a square centimetre and also a screen. This was a bright blue screen of stained gelatine, and it was possible to produce a spectrum which could not be distinguished with a spectroscope from daylight, given a certain source of light (and it would have to be different for different sources of light), a suitable screen could be made. But the economy of it would not be great, as was mentioned in the paper. From the look of the screen he should say it cut off about half the light, but if an artist wished to use them such screens could be made. Although the colour values would be those of daylight, anyone coming into a room from the street would say it was a blue light.

Dealing with the author's reference to 164 colours, Mr. Trotter mentioned that Dr. Edridge Green has an instrument by which he cuts the spectrum into bands of such a width that they appeared to be mono-chromatic. There were apparently 17 mono-chromatic bands, but Lord Rayleigh had now a method by which he could split up one of these bands into 15 which gave about 250 for the whole spectrum. The reference in the paper to dioptric globes reminded him that he had had to wait thirty years before his invention of dioptric globes had been heard of again.

Mr. Haydn Harrison was glad that the author had done away with many of the fallacies that existed regarding the efficiencies of mercury vapour lamps. The quartz lamp was given in the paper as 1·76 candles per watt. When the Cooper Hewitt and the Bastian lamps were first brought out, the efficiency was put at about 0·1 watt per candle-power; 1·76 candles per watt was a great deal nearer the actual efficiency.

The author had not stated whether his candle powers were Hefner or British. He concluded they were British, and if so, then the efficiencies of metal filament lamps were about 15 to 20 per cent higher than he himself got.

He did not think the Ulbricht globe could be of much commercial use, because the mean spherical candle-power of any lamp did not help the illuminating engineer. Was the candle-power given by the author mean hemispherical?

Prof. Marchant said yes.

Mr. Harrison asked how this was arrived at. They could not take the mean spherical and half it, and then call it the mean hemispherical.

Prof. Marchant said the mean hemispherical was double the mean spherical.

Mr. Harrison asked how the author knew it was by investigating with the Ulbricht globe. He did not see how it could be so.

Prof. Marchant said that in order to determine the mean spherical candle-power he multiplied the illumination of the milk glass by a certain constant. In determining mean hemispherical intensity, the constant was twice as big, provided *all* the light was given in one hemisphere and the flux of light was thus given off a hemisphere instead of a sphere.

Mr. Harrison said that when this was not the case the method was wrong.

For example, in a V flame arclamp the lower mean hemispherical candle-power would be approximately double the mean spherical but in the case of an incandescent lamp the mean spherical and mean hemispherical would be the same. He would like Dr. Marchant to clear that up in his reply. In conclusion Mr. Harrison thanked the author for the very interesting paper he had presented.

Mr. A. H. Seabrook said he had largely increased the life of his street metal filaments lamps by giving instructions to the men to switch the lamps on before cleaning the lanterns or the globes. The same would apply to metal filament lamps in domestic and commercial use. If this were more generally known by the public there would be a great saving.

He was inclined to think that modern reflectors represented as great an advance as metal filament lamps themselves. He referred to the Holophane globes and reflectors. He knew of

cases where by their use the consumption of current had been reduced by half, and yet there was the same amount of light as before. He had been able to effect considerable improvements in shop-window lighting by putting smaller lamps out of the line of vision in conjunction with Holophane shades and globes.

It seemed to him that the gas and electric supply people realized the enormous amount of work there is to do in illumination better than any one else. Every day one saw atrocious methods of illumination, and it would require co-operation between public and lighting authorities and societies like the Illuminating Engineering Society to educate the public in the right direction.

Mr. H. D. Wilkinson thought that the paper appeared to attach too much importance to aiming at uniform illumination in street lighting. In Mr. Haydn Harrison's recent paper to which the author had made reference in this connexion, it had, he thought, been shewn that, under certain conditions, uniformity would not be desirable, or at any rate appreciated from the public point of view. For instance, uniformity could be produced by raising the height of existing lamps in some cases, but unless the candle-power was increased at the same time this would lower the illumination within a certain radius of the source of light. It was more necessary to illuminate strongly street corners and crossings than intermediate positions, and it would be undesirable in many cases to concentrate the rays at too small a horizontal angle. Other considerations, such as glare, came in at very small angles. The dioptric principle and other devices for modifying the natural polar curve were very valuable, especially in the case of flame arcs, but the diversity co-efficient of 4 to 1, with lamps 25ft. high and 140 ft. spacing as mentioned by the author, was, in his opinion, as far as it was advisable to proceed towards uniformity.

Mr. Justus Eck thought it would have been preferable for the author to have adopted a uniform method of expressing the candle-power of different lamps. He noticed that Prof. Marchant had first referred to horizontal candle-power in connexion with metal filament lamps, and later on to other classes of candle-power. He had worked from the figures in the paper and arrived at a figure of 1·78 watts per mean hemispherical candle-power for metal filament lamps, which he agreed as being about correct, and would therefore like to see this inserted in the paper.

He questioned some of the figures relating to arc lamps, and especially those of the diversity factor. He also could not agree with figures given for the "Excello" lamp. He had with him some figures of practical tests, and with lamps placed 300 ft. apart and 35 ft. high, proving there was a diversity coefficient of only 2·5 to 1. The greater diversity coefficient in the paper might have arisen owing to the results either not being obtained with lamps fitted with the dioptric globe, or errors in erection, because it was essential with these globes to set the arc in the correct position; otherwise the resultant polar curve was both different, and less than, it should be. He had other figures which showed that for first class street arc lighting, as required by modern conditions of fast street traffic, a diversity coefficient of 4·1 could be obtained without great expense.

He did not agree with the view that arc lamps will be only used for outdoor lighting in the future. Only within the past few days he had been speaking to a borough electrical engineer who had been touring the country who expressed his surprise at the large number of drawing offices in engineering works which had inverted arcs.

He could support this from actual experience on the matter himself. He also believed there was a future for indirect lighting by arc lamps in engineering works and factories. This system of illumination lent itself better to supervision of the employees owing to the distance which could be seen by them; with indirect lighting a foreman could see the whole length of a shop as easily as in daylight. The lighting of interiors of retail shops was another

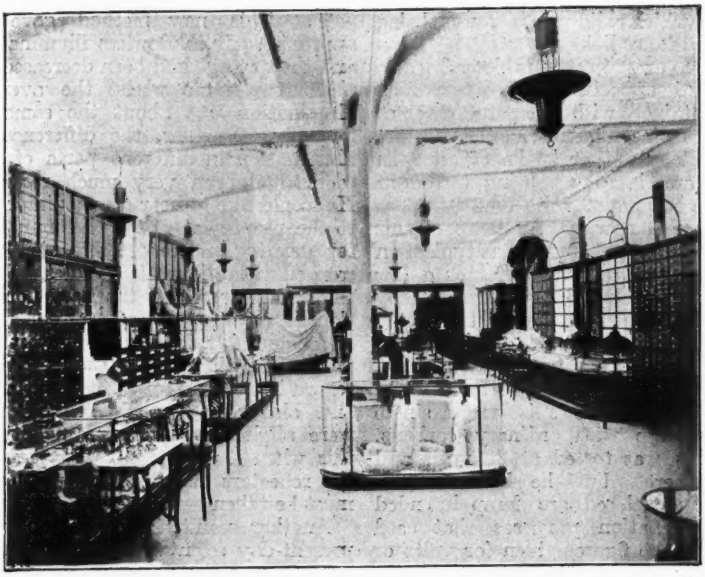


FIG. 1.—Lighting of Messrs. Debenham & Freebody's Premises, Wigmore Street, London, by Inverted 10 amp. Arc Lamps. (*Mr. J. Eck*)

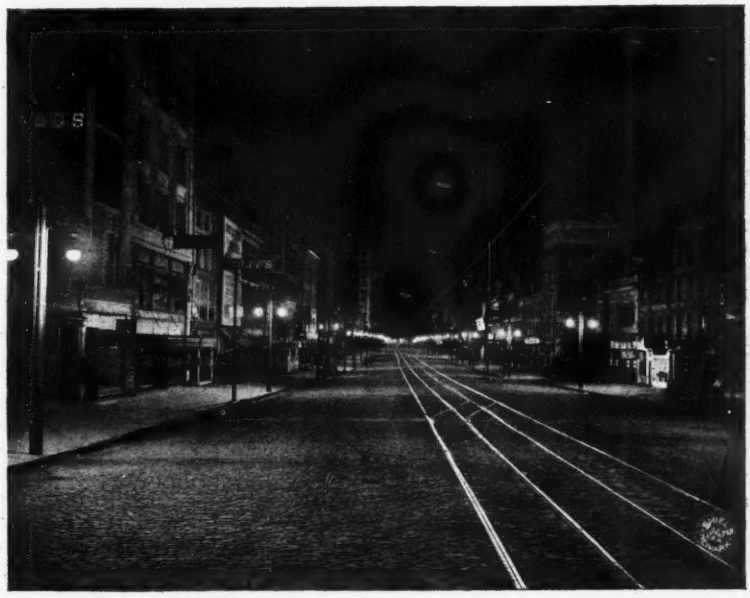


FIG. 2.—Broad Street, Newark, U.S.A., 10 ampere A. C. Excello Arc Lamps arranged two on a post at the sides of the street. Lamps 50 to 75 ft. apart, globes only 16 ft. above ground. (*Mr. J. Eck.*)

field in which solid progress was being made with arc lighting.

The figures in the table were also directly in opposition to the figures he had obtained with the same class of measuring instrument, viz., the Ulbricht globe. The author spoke of an open flame arc lamp as being tested at 7 amperes and 40 volts or 280 watts. He did not know of any lamp of this class that was put forward as typical on such a low current, and at such a low watt rating. The voltage was decidedly too low. He had found that the candle-power of flame lamps increased very considerably as the voltage rose from 40 to 46 or 47. Another of the lamps on the author's list was a single enclosed arc with ordinary carbons, and this was tested at 86 volts and 8·5 amperes, but he knew of no ordinary enclosed arc lamp intended for illumination purposes that used either of the figures given for volts or amperes; he should like to know whether the lamps were tested at the current and voltage recommended by their makers.

Mr. Eck then presented some slides as good examples of modern street lighting by arc lamps, pointing out the suitability of arc lamps for the central lighting of streets. He also showed some slides of the exterior and interior lighting of retail shop premises, including shadow-free, colour-true lighting of drapery shops by direct and alternating current.

PROF. J. T. MORRIS referred to an instance in which two tantalum lamps in series, one in a kitchen and the other in a passage, showed great inequality in length of life, the one in the kitchen breaking down much sooner than the other. Was this due to the influence of the extra heat in the kitchen? He had tried 17 lamps, and in every case but two the lamp in the kitchen went after an average life of 4 weeks. He had since replaced them with tungsten lamps and the kitchen lamp had lasted for 10 months.

With regard to the lighting of drawing offices at the East London College he had had occasion to replace inverted arcs by tungsten lamps in three drawing offices, Holophane reflectors being used. This new method gave an approximately shadowless illumination and the wattage had been decreased to about two-thirds whilst the average illumination was about the same as formerly. Further, the difference in illumination in different parts of the rooms had been very much reduced. He would like to hear some opinions as to the proper intensity of illumination for drawing offices. Prof. Marchant worked with about 3 ft. candles. With the inverted arcs at the East London College, certain parts of the rooms had as much as 8 ft. candles, but now it was fairly uniform at 6 ft. candles. With regard to cleaning metal filament lamps and also reflectors whilst the lamps were alight, there was a difficulty in this when it was necessary to remove the reflectors, as obviously the lamps must be taken out to do so.

Another point in connexion with present-day scientifically designed reflectors was the necessity for placing the lamps in exactly the right position. When people used various makes of metal filament lamps it was possible that the light-giving part of the lamp might not be in the same position in respect to the socket, and consequently the distribution of the light was greatly altered.

The subject of the proper kind of lamp to use in a fog had been often discussed and there seemed to be some difference of opinion. At the present time, in connexion with one of the principal docks, the matter was undergoing careful consideration, and it was a question as to whether a certain series of flame arcs should be replaced by high pressure gas lamps as the latter were supposed to be seen better in white fogs which occurred on the river.

MR. GASTER expressed his interest in the paper and his appreciation of the author's reference to his Cantor Lectures.

It was very interesting to trace the historical development of metallic filament lamps during the last few years. He recalled how, when lecturing before the Royal Scciety of Arts in 1906 he had exhibited what he believed was the first metallic filament burning at approximately 1 candle per watt

ever shown publicly in this country; this lamp, which required 37 volts to give 30 candle-power, was then regarded as a wonderful advance. Subsequently, during the discussion of Mr. Swinburne's paper before the Institution of Electrical Engineers early in 1907, he had exhibited a 200 volt metallic filament lamp at a time when the common belief seemed to be that such lamps could not be made for pressures over 100, and even then only for exceptionally high candle-power. Yet to-day we had 100 volt 16 candle-power and 200 volt 25 candle-power lamps available. The difficulties of manufacture were being gradually overcome, and it was now possible to secure lamps which were much less fragile than the earlier varieties, blackened to a less extent, and would burn in any position.

He wished to draw particular attention to the new drawn tungsten wire lamps, several specimens of which he had on exhibition. It was claimed that by this process excellent results as regards life and resistance to shock were obtained.

There was one point, however, on which Mr. S. E. Doane had recently laid stress, which he desired specially to commend to the notice of lamp makers, namely, the desirability of standardizing the dimensions of lamps. Mr. Doane had pointed out the necessity of securing a certain standard distance between the cap and the filament so that, with a given shade or reflector, the position of the filament with regard to the reflecting surface was standardized. Under these conditions an engineer could predict with certainty, what the illumination, using certain lamps and shades, would be, and he could also feel confident that when the lamp gave way and was replaced by another of the same kind, the distribution of illumination would not be prejudiced thereby. Standardization in this direction had, he understood, been found very beneficial in the United States, and he anticipated that it would likewise be found desirable in this country.

Details had been given regarding a number of lamps. There was one new feature of the Moore lamp which seemed worthy of mention. It had now been found possible to make this in the form of small units, having a relatively small length of tube, and it was said that small portable lamps of this kind had given very good results in connexion with textile factories in which correct colour-definition was very important. The Carbon dioxide Moore tube was claimed to give a light which resembled daylight very closely in colour, and it was said to be coming into use for colour-matching work on that account, since it enabled certain processes which would otherwise have had to terminate when daylight failed, to be continued by artificial light.

Mr. P. J. Waldram, F.S.I., said that few things had been more gratifying and indeed profitable to architects than the great advances which had been made during the last few years both in gas and electric lamps. But a good deal of the advantage gained was discounted by the fact of lights being placed in positions, and amongst surroundings, which were scientifically unsuitable. There was a great deal of educational work still to be done amongst architects with regard to illumination, and every effort should be made to arouse architectural schools to a sense of their responsibility with regard to this far too neglected subject. It was essentially a subject where the architect, the electrician, and the illuminating engineer should combine. For instance, in lighting Large Concert and Meeting Halls, Council Chambers, &c., the electrician would probably say that the most economical method of lighting, both in wiring and upkeep, would be to use high power lamps without shades. The architect would instantly object on account of glare; but the illuminating engineer could point out that if the lamps were sufficiently high up to prevent the direct rays entering the eye at an angle of less than 60 degrees with the horizon, then those lights, although still in the possible field of vision, would not be found trying to the eyes. The electrician would probably reply that lamps as high up as that would lose in efficiency, and might even quote the

old rule that illumination varies inversely as the square of the distance between the illuminant and the surface illuminated. The illuminating engineer could then point out that it does not do so in the case of the Ulbricht globe, and that if the architect would kindly provide white ceilings and walls coloured with tints possessing a high co-efficient of reflection, his client would receive not only the full spherical candle-power of the lamp, but probably more.

He had been particularly struck by the excellent lighting effects obtained in a large seaside skating rink 125 ft. by 94 ft., with a white arched ceiling 35 ft. high, lighted temporarily with five 3,000 c.-p. flame arc lamps close to the ceiling. The floor was amply lighted and the whole general effect was brilliant; yet there was no glare and the light was quite soft and pleasing. He ventured to make the somewhat daring suggestion that a scientific study of the effect of light walls, ceilings, and floors would show that in large rooms unscreened (and therefore economical) lights might be used with æsthetic advantage to a greater extent than might seem feasible; and that in similar rooms it would be found that such surroundings not only effect great economy and improve the general effect, but that they turn a room into a form of Ulbricht Globe in which lights can be placed in almost any position and in which nearly their total output of light is utilized.

In this connexion Mr. Waldram instanced the case of a library with dark walls and ceilings where a powerful shaded oil lamp gave a poor illumination when placed only a few feet away; he compared this interior with a large bedroom. with a white ceiling, very light yellow walls, and a large bed with a white cover, in which a single candle afforded quite a fair reading light over nearly the entire area of the room.

Mr. W. R. Rawlings said he would like to hear something about the effect that the variation of voltage had in connection with incandescent lamps. Electric supply undertakers did not give a standard voltage, and it might be due to this that complaints were made as to the short life of lamps compared with the standard given by the makers. It would have been most interesting to have had some figures as to the life and efficiency of lamps with varying voltages. He thought a great deal too much was made of the 1 or 1·2 watt per candle lamp, because they were told by the makers to put a 105 volt lamp on a 100 volt circuit, and with these conditions he should like to know the efficiency. It was a misstatement of fact to call a lamp a 1·2 watt per candle and then be told to use it on a lower voltage than it was intended for. He had challenged some makers, and had been told that the so-called 100 or 200 volt circuit was more often 5 to 7 per cent higher. If the lamps were so susceptible to voltage it was due to the supply station engineers to do something to bring about a more constant voltage and so improve the efficiency of the lamp.

Mr. Ritchie inquired in what plane the polar curve of light distribution of the mercury lamp was obtained, *i.e.*, was the curve obtained in the plane of the tube or at right angles to it? What difference did this position make in the nature of the curve? He would also be glad if Prof. Marchant would state the consumption in watts of this lamp, and inform him whether the figures for candle-power were obtained with or without the outer globe.

With regard to the inverted arcs replaced by Prof. Morris, he would like to know whether these were *true* inverted arcs, as distinct from merely ordinary arcs used for indirect lighting, and whether they were provided with scientifically designed reflectors. This last point was of considerable importance. Again, he would like to learn what was the height of the lamps from the ceiling, as a great deal depended upon the scientific adjustment of the distance of the lamps.

Mr. J. S. Dow referred to some results recently obtained by Mr. Kinsloe in the United States in connexion with glow-lamps run off an alternating current supply. This observer found that both the life and the efficiency were materially affected by the nature of the wave, results differing by as much as

50 per cent being obtained according as a sine wave or a peaked wave was used. In view of Prof. Marchant's experience that even an intermittent current of the kind described in the paper yielded as good results as a continuous one it seemed surprising that the relatively small fluctuations in physical conditions during the cycle of operations of an alternating current could have so marked an effect.

Prof. Marchant had referred to the method of obtaining a "white" light by mixture of the light from incandescent and mercury lamps. An interesting experience had been reported by several observers in the past, who found that the individual illuminations in such cases did not add up to the combined value. Possibly this might be so at low illuminations. It was, however, interesting to observe that, according to some tests mentioned in a recent number of *The Illuminating Engineer*, the intensities of the separate illuminations from the mercury vapour lamps and metallic filament lamps in the Lecture Hall of the Institution of Electrical Engineers did add up very approximately as they should do.

The author had referred to the method of testing the "whiteness" of light by analysis by the three-colour process. Some people considered a light to be a good approach to daylight if it enabled them to distinguish delicate shades of colour. It seemed, however, that the only scientific method of comparing the colours of two lights was to go through the spectrum, step by step, and compare the intensities in the different regions.

There was one other point on which Prof. Marchant might be able to afford some information. Dr. Cooper Hewitt, it was reported, had succeeded in making fluorescent reflectors which, when placed above mercury lamps, fluoresced with such vividness as to produce the missing part of the spectrum, and thus give an approximately white light. If this could be done in a practical manner it seemed a process with great possibilities.

Mr. J. G. Clark (communicated): I should like to add a few remarks with reference to the question raised by Mr. Haydn Harrison regarding Prof. Marchant's use of the Ulbricht Globe to determine mean hemispherical candle-power.

As I understand Prof. Marchant's explanation, his interpretation of mean hemispherical candle-power seems to differ from that usually adopted. The figures given are based on the assumption that the whole of the flux is concentrated in one hemisphere, a condition of things that seldom exists. In view of the great desirability of standardizing photometric methods and nomenclature I hope that Prof. Marchant will make this matter clear. In any case if data for the determination of the true mean hemispherical candle-power, viz., complete polar curves of light distribution, were available, it would be better to revise all figures based on the above supposition so as to prevent any possible ambiguity.

Mr. A. S. Briggs (communicated): I question whether the suggestion made by Mr. Wilkinson that street corners and crossings should be specially brilliantly illuminated is entirely satisfactory. It seems to me that any advantage gained by providing special lighting for the most dangerous portions of streets is discounted by the fact the contrast makes it more difficult to see the adjacent less brightly illuminated regions. The effect of local bright spots is to dazzle the eyes and cause closing of the pupil-aperture, especially in the case of drivers of fast moving vehicles, &c., and to produce the impression that more weakly illuminated parts of the roadway are darker than they really are.

Prof. Marchant, (in reply):— I must apologize for not having mentioned Mr. Trotter's classical researches. His work in connexion with the spectroscopic examination of light is so important that no paper professing to deal with the production of a daylight spectrum should omit a mention of it.

Luminous efficiency may be defined for a given room as the ratio between the total flux of light received on the area that requires illumination to the total flux of light emitted by the lamps. The flux of light over the area is the

intensity of the illumination in foot-candles multiplied by the area in square feet; and that may be considerably greater than the total flux of light emitted by the lamps if the area on which the light is received is a non-absorbing one. The light received on the area may be reflected or diffused back to the ceiling and walls, and thence reflected or diffused on to the area again, so that the light over the area would be, as it were, received several times over. To say that the luminous efficiency is greater than one is really equivalent to a statement of the well-known fact that the illumination of a room can be greatly improved if the walls, ceiling, and floor are non-absorbent.

With regard to Mr. Trotter's account of some methods that have been adopted to produce the daylight spectrum by a special screen, it is, of course, obvious that the efficiency of an ordinary lamp with such a screen would be very low indeed. The statement that the only method of producing a light similar in all respects to daylight is to use a source whose temperature approximated to that of the sun should be modified. The only method of producing a light similar in all respects to daylight, *with maximum efficiency*, is to use a source whose temperature approximates that of the sun.

It will be convenient here to refer to Prof. Thompson's remarks as to atmospheric aborption. The point I intended to emphasize was that the eye appears to have adapted itself so as to respond most readily to those light vibrations received from the sun which are of maximum intensity. If the temperature of the sun is determined by using Wien's law (that is, that $\lambda\tau=2940$, where λ is the wave-length of maximum emission intensity in μ (10^{-6} metres), and T is the absolute temperature of the radiating black body in ° C.) then that temperature will be the temperature at which an artificial source of light should work to give maximum efficiency. This may not be the true temperature of the sun, if we have selective absorption by the atmosphere such as Dr. Thompson refers to, but it is the best temperature for an artificial source which has to supply light for the eye.

With regard to Mr. Haydn Harrison's question as to the Ulbricht globe, the point may be made more clear as follows. The Ulbricht globe measures the total flux of light if this light is radiated in all directions from its source. The globe test will, of course, give the mean spherical candle-power. If, however (say by reflectors), the light is distributed so as to give illumination over a hemisphere, the globe test, if it is made with the shade in position, will again give the total flux of light, but the figures by which the illumination of the milk-glass on the globe has to be multiplied to give the mean hemispherical c.-p. of the lamp will be twice as great. The multiplication by 2 to give the mean hemispherical c.-p. is only permissible when *all the light* is given to one hemisphere. It would be quite wrong, of course, to take a lamp, such as an incandescent lamp, measure its mean spherical c.-p., and then multiply by 2 to get its mean hemispherical candle-power. If the mean hemispherical c.-p. of a lamp which does not give all its light to one hemisphere has to be determined, it can be done quite easily in the Ulbricht globe by suspending the lamp in such a way that only the light given out over a hemisphere falls on the globe surface. For example, with one of the old-fashioned open type arc lamps the mean hemispherical c.-p. can be found by fixing the lamp so that the arc is on a level with the top of the Ulbricht globe, *i.e.*, with the lamp globe partly in and partly out of the Ulbricht globe.

With regard to what Mr. Wilkinson has said, it is of course easily possible to increase illumination at any given point by increasing the number of lamps. There seems to be little difference of opinion among illuminating engineers as to the advisability of securing uniform illumination along a street.

With regard to Mr. Eck's remarks, the best efficiency for metal filament lamps was 1·2 watts per mean hori-

zontal c.-p. The mean spherical c.-p. was about 0·8 of the mean horizontal c.-p., so that for a metal filament lamp that would give about 1·5 watts per mean spherical c.-p. At the same time, if this correction is made for metal filament lamps it would be only fair to give the watt consumption per mean spherical c.-p. for arc lamps, and in the best lamps tested the result would be 0·45 watts per mean spherical c.-p. In the tests referred to at Liverpool, the "Excello" lamps were not fitted with dioptric globes.

As to replacing flame lamps by metal filament lamps in drawing offices, I am speaking from personal experience, but I am not at all surprised to hear that the "Excello" lamp was used for this purpose. Speaking generally, however, I still do not think my statement was very far from the truth, and that arc lamps will, in future, be used chiefly for street lighting. The figures in the table for open flame arc lamps were obtained with a lamp working at its rated voltage and current; I have, however, figures which entirely bear out what Mr. Eck had said as to the increase in efficiency obtained by increasing voltage and current. With the lamp tested, the mean hemispherical c.-p. increased to 2470 when the voltage was raised to 48, and the current to 8·3 amps. and the mean hemispherical c.-p. per watt increased to 6 under these conditions. Figures for the "Excello" lamp will, it is hoped, be included in the paper in its final form.

In reply to Dr. Morris's question I have found an illumination of from 3 to 4 feet candles quite suitable for drawing office work.

With reference to what Mr. Waldram said, there is no question that the illumination of rooms could be enormously improved if architects paid more attention to the character of the wall covering. In reply to Mr. Rawlings I may add that it is easy, if curves for voltage and efficiency are consulted (see *Electrician*, vol. lviii, p. 319), to determine approximately the effect of voltage on life. It is only necessary to find in any given case how the watts per c.-p. decrease with voltage, and then, from the curve given in Fig. 2, the life for lamps working at various voltages can be easily compared.

Mr. Seabrook's reference to the increase in the life of metal filament lamps effected by cleaning them when the lamps are lit, entirely confirms the opinion expressed in the paper as to the real reason for the frequent breakages of metal filaments.

THE PRESIDENT, in proposing a vote of thanks, mentioned the magnetite arc which, he believed, had never been publicly used in this country. Through the courtesy of Dr. Steinmetz of the American General Electric Co. he had one in his private possession, and had made a few tests upon it. It was in several respects a remarkable lamp. The light came from the arc, and not from the carbons. In fact, the upper carbon was simply a solid piece of copper, and the lower one a composition of oxides, mainly magnetite. The flame was $\frac{3}{4}$ in. long and $\frac{1}{4}$ in. thick, bounded top and bottom by solid stuff, that did not get quite hot. The light was thrown very nearly sideways, which was excellent for street work. The efficiency was very high, the light being very white, and the candles per watt very considerable. They might ask why it was not more used in this country. One reason was that the little thin column of white arc was apt to wander round and round the electrodes; thus while the total quantity of light given out was large, it was thrown first to one side and then to the other, and the resulting illumination was not steady enough nor regular enough as compared with that to which English eyes were accustomed.

It was an extremely beautiful phenomenon that had been mentioned by Prof. Howe. He himself had a number of tungsten lamps which showed the same deposits, but they did not all appear green by transmitted light. One was a bright blue. He had supposed that some of his lamps did not acquire the shadow during ordinary running, but at the moment the filaments gave way, there being a sputter and an arc at the point of fracture. It was clear, however, that in Prof. Howe's lamp the phenomenon had been going on without any fracture, the

deposit having been emitted at a point, where, in a sense, the electricity was abruptly turning a corner. There seemed an obvious connexion with the phenomenon described a year and a half ago in the United States by Prof. Niper of St. Louis, who was investigating what was happening at a sharp corner in an electric circuit. He found that at such corners there was something going on in the nature of an emission or a radiation, and the introduction of a photographic dry-plate seemed to indicate the discharge apparently of electrons. Whether the phenomenon was the same he did not know, but he thought it deserved further investigation.

[As we go to press we receive interesting communications, from Prof. Elihu Thomson and others, dealing with the list of *queries on electric lighting* published in our last number, p. 739; we propose to deal with these in our next.]

Recent Progress in Gas Lighting.

(Additional communications received in response to the series of queries on this subject, published on p. 732 in the last number of this journal.)

MR. C. O. BOND (United Gas Improvement Co., Philadelphia, U.S.A.).—

(1) *What is the maximum efficiency (candle-power per cubic foot of gas consumed per hour) attainable in practice at the present time, and under what conditions as regards pressure, &c.? What do you consider the most accurate method of expressing this quantity (i.e. in terms of mean spherical, mean hemispherical, or candle-power in some prescribed direction)?*"

The best efficiency we have found thus far is on a certain type of high-pressure lamp, which, under 2 lb. pressure and with a consumption of 23·23 cu. ft. of gas per hour, produced a mean spherical candle-power of 729. This lamp contains two inverted burners, uses rag mantles, and is furnished with a clear globe. Based on mean spherical candle-power this would amount to 31·4 mean spherical candle-power per cubic foot of gas per hour. The distribution curve of the lamp, however, showed a candle-power at 20° below the horizontal of 1225, which is equivalent to saying that the maximum candle-power of this lamp in one direction is 52·8 candles per cu. ft. of gas per hour. Unfortunately in many cases no qualitative description of the gas is given, and we may draw our own inferences as to whether this was produced with a 10 candle-power coal gas or a 30 candle-power water gas, or even whether it was produced with a natural gas containing over 1,000 heat units per cu. ft. For this reason it is the practice in the Photometrical Laboratory of the United Gas Improvement Company to make all such tests on stored gas, which gas at the time of test is examined for its specific gravity, heating value, and photogenic value.

Every one is, or should be, at this day familiar with the advantages to be had by the proper use of reflectors, and this point is well brought out in Mr. Goodenough's paper. For example, if the maximum of light is desired below the horizontal plane, then, as a matter of efficiency, inverted mantles would naturally be chosen in which there would be the least cause for redirection of rays otherwise ineffective below that plane. If, on the other hand, the greater part of the light is desired above the horizontal plane, as in indirect systems, then we would expect to utilize for such purposes upright mantles in which there is naturally a much higher percentage of the light thrown above the horizontal than with the inverted mantles. From this statement we conclude that the most accurate method of expressing the efficiency of a light source is in terms of its total light radiated, and we prefer to express this in lumens rather than in mean spherical candle-power, though these are directly related.

While opinion is not undivided on the statement that the light produced by means of incandescent mantles is

directly related to the b.t.u. value of the gas used, yet experience and the stand taken by many eminent physicists on this question would seem to indicate that the statement is a nearly true one. Accepting this, our method of rating the efficiency of a light source, then, is to state the lumens per b.t.u. derived from it under the best conditions, and using this basis of rating, the high-pressure lamp referred to has an efficiency of 0·631 lumens per b.t.u. per hour.

(2) "*How long, on the average, should mantles intended* (*a*) *for low pressure indoor lighting,* (*b*) *for outdoor high pressure lighting, be allowed to be used before they are replaced?*"

The answer to this question would depend upon circumstances. With the high-pressure lamp there is, as a rule, a short interval of life after the first hole appears before the mantle is unfit for further use. With the low-pressure lamp, on the other hand, a mantle may continue in use with a hole of small size for a considerable length of time, the length of this time depending entirely upon whether the hole enlarges to such an extent as to endanger the glassware or to lower the candle-power of the lamp a perceptible amount.

It is doubtful if the average person, unless there be some constant light source for the purpose of comparison, could, without photometric assistance, distinguish a reduction in candle-power of less than about 10 per cent; and when it is considered that fully that much loss is occasioned by dirty glassware while the mantles remain in good condition, it can be seen that such a loss of 10 per cent will probably not occasion complaint.

Another factor enters here. With a good quality of mantle, in which the loss in candle-power is due to shrinkage alone and not to holes in the mantle, a proper readjustment of the burner would cause a decrease in the gas supply necessary to render the mantle properly incandescent, and thus, while there might be a loss of 10 or 15 per cent in the candle-power of the light, there also would be a corresponding decrease of 10 or 15 per cent in the consumption of the gas, so that the efficiency of the light would remain practically as high as before. This we know to be the case with many good grade mantles; therefore a consumer having an excess of light in his installation, or using a portable light permitting him at will to vary its distance from him for proper illumination on his printed page, might note the decrease in light given by his lamp, and yet he would be satisfied so long as there was a corresponding decrease in the cost of the light.

In the case, however, of installations worked out by an illuminating engineer, where a definite illumination was required on a given plane, and where it was the thought of the illuminating engineer and the gas company to keep his working plane adequately illuminated, there would be injustice in permitting his light to depreciate 15 or 20 per cent when, in the mind of the consumer, the desirable thing was adequate illumination and not cost.

In making life tests of mantles submitted to us, it is our practice to continue the test for a period of 1,000 hours. Mean horizontal candle-power readings, consumption of gas, breaking strength of mantles, and the weight of the ash in the mantles are determined at the end of periods of 1, 25, 75, 100, 250, 500, and 1,000 hours. A life size photograph of the mantles is also taken.

From this information we may obtain an efficiency curve based on the mean horizontal candle-power per square inch projected area per b.t.u. per hour.

On an efficiency so based we have had good upright mantles which showed a loss of but 8 per cent efficiency in 1,000 hours, and have had poor mantles that showed a loss of 40 per cent efficiency in the same time.

Query No. 3, as to our experience with automatic control of lamps, we are not in a position as yet to answer. Tests are now going forward on this line of investigation.

Query No. 4 is more particularly a subject for a Commercial Department to answer.

Query No. 5, as to the intrinsic

brilliancy of modern lamps and the desirability of diffusing globes.

I certainly do think that the eye should be shielded from the high powered sources by such globes. In the case of indoor lighting there is a wide variety of glassware to be chosen from. Some of it, bearing the name of diffusing glassware, is not of a properly diffusive nature, for while it obscures the outline of the mantle or luminous source, it yet permits a bright spot of possibly one-half the original brilliancy to be seen by the eye. There would seem to be no excuse for glassware of this nature, when a quality of Austrian opal glass can be obtained of a pure diffusing quality and yet approximating not more than from 10 to 15 per cent in its absorption, so that a 50 mean spherical candle-power light source enclosed within a 6-in. globe of this type will show the globe to be uniformly luminous and yet the intrinsic brilliancy will be reduced from 30 candle-power per square inch to about two candles per square inch.

When the eye is offended by an excess of light, it still remains to be determined to what extent this is due to the intrinsic brilliancy of the light, and to what extent it is due to the quantity of light. We hope somewhat later to arrive at a conclusion on this subject.

DR. C. R. BÖHM (Berlin) :—

1. The maximum efficiency yet attained in practice with high-pressure gas lighting corresponds with a consumption of about 0·45 litres per H.K. (58 candles per cubic foot). Heilberg, however, is reported to have obtained a result as low as 0·38 litres per Hefner by means of a special inverted mantle worked on the Millenium system. He obtained 856 H.K. with a consumption per hour of 325 litres, the candle-power being measured at 10 degrees below the horizontal. In summarizing results it is certainly desirable to specify the particular direction in which measurements are made and to take the mean of readings at intervals of 45 degrees. In making comparisons between different lamps it is essential to bear in mind the difference in the form of the mantle and the consequent variation in intensity at different inclinations.

2. High pressure mantles can be secured which require renewal only every 500 hours in the case of indoor lighting, and every month in the streets. In the latter case, however, the results vary somewhat according to the amount of shock experienced, the deposit of dust, &c. A reduction in candle-power of about 20 per cent may be looked for before the mantles are replaced.

3. Automatic ignition and extinction has in all cases commended itself for high-pressure street lighting. In the case of interior lighting it is usually only applied to lamps which are hung high up or in somewhat inaccessible positions.

4. The supervision and maintenance of installations for consumers may be undertaken by gas companies with advantage. By this means a consumer may be assisted to make a saving in his expenses, and he is much more likely to be satisfied with his conditions of illumination. The advice of the gas company and the contractor should always stand at his disposal.

5. In the case of high-pressure lights for street lighting no diffusing globe is necessary; in the case of indoor lighting mantles should be suitably screened.

(Attention may also be called to an interesting paper by Mr. N. MacBeth, presented at the Annual Convention of the Illuminating Engineering Society in the United States, and now published in the *Transactions* for November. The paper deals with the effect of pressure variation on the performances of incandescent and flat flame burners, and is illustrated by a number of curves and photographs showing the change in the flame. In a large number of cases an increase in pressure beyond that normally employed leads to the same efficiency as before, or even to an improvement; in others, however, an increase in pressure and in gas-consumption may be attended by a fall in lighting efficiency.

ED.)

Short Notes on Illuminating Engineering.

From all Sources.

The Embankment Lighting.

"It is not the first time we have referred to the Embankment lighting. We do not complain so much of the old open type arcs on standards. They are poor enough in all conscience, and should be replaced; but along the river wall itself are some ancient arcs in still more ancient lanterns. Few people realize that these are arcs at all; if it were not for the colour they might be colza oil lamps. Even the colour is partly disguised by pea-soup dirt."—*Elec. Times*, Dec. 1st, 1910.

"Punch" on Illuminating Engineering.

So many varied journals and papers now habitually refer to lighting matters that we felt sure it could only be a question of time for Mr. Punch to take the subject up.

We are not disappointed. In *Punch* for Dec. 14th an amusing account is given of the rehearsal of 'Salome.' The Prophet had taken up his station at the bottom of the well, and the time came for his voice to sound forth. But no voice came—"....he was reported to have arrived—by one of those lower entrances which habitually occur in Syrian wells—and to have sent up word that he could'nt see to read his score, the lighting arrangements at the bottom of a well being almost always inadequate." Eventually, however, this state of things appears to have been remedied and the singing began. But we believe this instance of a demand for better illumination at a rehearsal to be by no means unique.

"The Best Lighted Building in the World."

In these terms *The Electrical Review* of New York describes the exterior lighting of the building shown in the accompanying illustration, which contains the new offices of the Denver Gas and Electric Light Co., U.S.A.

The whole of the outside of the building is studded with Mazda incandescent lamps, the total candle-power of which is stated to be 200,000. The architectural lines of the building are followed

by the lights, and the effect is said to be very remarkable. Large crowds—"the largest that has ever assembled in the streets of Denver"—gathered to view the initial turning on of the lamps, a ceremony which took place on the evening of November 12th. The Mayor of the City turned on the controlling switch at 8 P.M. precisely, and a reception was afterwards held. the new premises being visited.

"Silhouetting" in Street Lighting.

MR. P. S. MILLAR, in a paper before the New York Section of the American Illuminating Engineering Society, calls attention to an aspect of street illumination not always sufficiently appreciated, namely, the importance of the discernment of large objects by "silhouetting." He points out that we very frequently become aware of objects in the street —approaching vehicles, and so on— not so much by the direct light reflected from them as by the contrast which they present as a dark object against a more brightly lighted background.

Hence the distant lamps are as important to an observer as those in his immediate vicinity. In this connexion it is well to remember that, within wide limits, the apparent brightness of a surface is independent of its distance away. Thus in order to see a vehicle or pedestrian by this silhouetting effect, it is only necessary to provide a substantially bright street, the distance of the background formed by the street being immaterial.

Searchlights and Flame Arcs at the Panama Canal.

IT is stated that the work of constructing the great Gatun dam in connexion with the Panama Canal has been greatly facilitated by the powerful electric lighting employed. Searchlights have been mounted on the towers, to which the cableways used in transporting loads are fixed, and they have been supplemented by flame arcs strung in rows of four between each pair of towers. The combined effect of these two methods has enabled night work to be carried on satisfactorily, and has accelerated the rate of progress considerably.

Appreciation of Scientific School-Room Lighting.

A NUMBER of experiments on the lighting of class-rooms, undertaken at the request of the Board of Education in New Jersey, U.S.A., are described by Messrs. G. W. Knight and A. J. Marshall in a paper before the American Illuminating Engineering Society (New York Section). By the final scheme adopted, utilizing tungsten lamps and Holophane reflectors, a mean illumination intensity of about 3·65 foot-candles was obtained.

It is interesting to note that there was at first considerable objection to the new scheme on the part of the instructors in the school, who imagined that, because the light sources were further away from the desks (and probably because the glare had been removed by the aid of diffusing globes), they were not obtaining such a brilliant light as before. As a matter of fact the illumination had been considerably increased, and yet the cost of lighting had been practically halved. However as the value of the new system began to be appreciated by the instructors and the pupils, they changed their views, and now give it unqualified praise.

A Forthcoming Course of Lectures on Illumination.

REFERENCE has frequently been made in these columns to the need for better facilities in the direction of courses of lectures on illuminating engineering.

We understand that a step in this direction has been taken by the WESTMINSTER TECHNICAL INSTITUTE (Vincent Square, London, S.W.), under the direction of the London County Council, which has arranged for a special series of **six lectures on Illumination** to be delivered by MR. J. S. DOW early in the year. The lectures will take place on successive Fridays at 8 P.M., commencing on Friday, January 13th. They will be illustrated by the exhibition of different types of lamps, and modern systems of illumination, and other apparatus, and special reference will be made to practical applications such as shop, library, and street-illumination, &c.

Full particulars can be obtained on application to the Principal, at the above address.

TRADE NOTES.

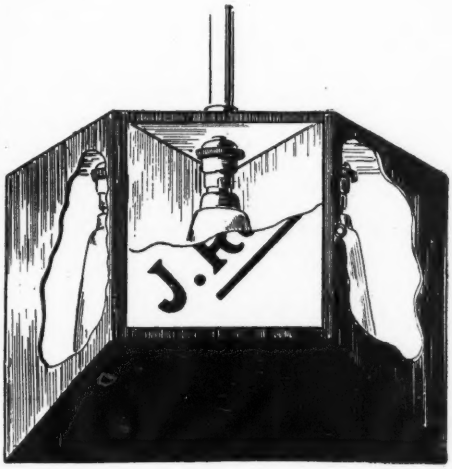
[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

A Combined Reflector and Illuminated Sign.

A new type of reflector, the back view of which is shown here, is being brought out by the **Sun Electrical Co., Ltd.** (118–120, Charing Cross Road, London, W.C.) under the name of "LUMIN-AD." The Reflector is made up of three compartments, each containing a lamp; two of these face the shop-window, whilst the third faces outwards, and illuminates any sign which may be inscribed on opal or coloured glass.

It is pointed out that if the centre lamp is wired independently of the others, it can be left on at night when the lamps lighting the window are turned off, thus serving to keep the name of the shopkeeper before the public.



Tantalum and "Onewatt" Lamps.

IN connexion with their specialities for Street Lighting, Messrs. Siemens draw our attention to the fact that they are placing on the market a line of 50 C.-P. "ONEWATT" LAMPS for 100-130 and 200–250 volt circuits. We understand that a large contract for TANTALUM LAMPS for use in ship lighting has recently been placed with **Messrs. Siemens Bros. Dynamo Works, Ltd.** (Tyssen Street, Dalston, London, N.E.), by an important ship-building firm.

FROM **The British Central Electrical Co.** (84, Hatton Garden, London, E.C.) we have received a price list of "EFESCA" LAMPS, and also some particulars of their "ECLIPSE" ELECTRIC HEATERS, of the Convection and Radiation types.

Cryselco, Ltd. (Kempston Works, Bedford) have sent us a neat little booklet, entitled the 'Autobiography of an Electric Lamp,' which is followed by a short price list of the various forms of METAL FILAMENT LAMPS made by this firm.

Gas Lighting in the West-End.

The new gas lamps in Regent Street, Piccadilly, Pall Mall, and neighbourhood, which have been installed by the **Gas Light and Coke Company** during the past fortnight in place of the electric arc lamps previously employed for lighting the main West End thoroughfares, have attracted a good deal of attention.

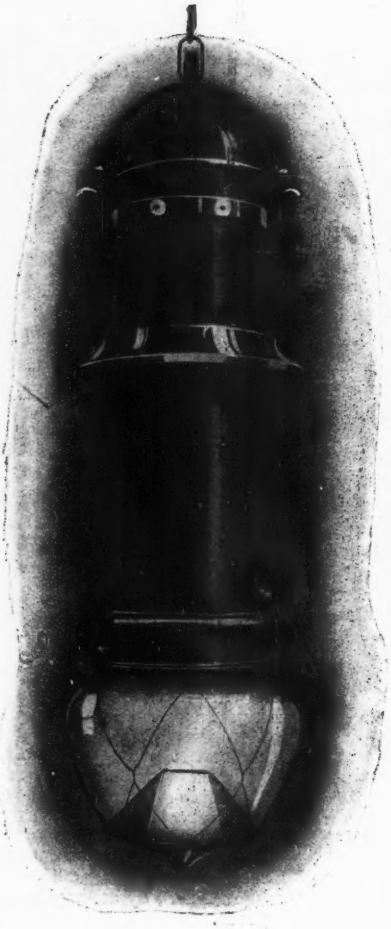
There can be no question of the powerful illumination given by these lamps, which compares very favourably with that in many less up-to-date portions of the city. It may be hoped that the new installation will serve to induce the authorities in backward districts to bestir themselves and introduce the most recent modern improvements.

Another Reduction in the Price of Gas.

WE are informed that, for the fourth year in succession, the Gas Light and Coke Company are making their consumers a New Year's gift in the shape of a reduction of 1*d.* per 1,000 cubic feet in the price of gas, this last reduction bringing the price down to 2*s.* 7*d.*

The "Multax" Flame Arc Lamp.

Messrs. The Globe Electric Co., Ltd., send us a pamphlet dealing with their "MULTAX" LONG-BURNING FLAME ARC LAMP, an exterior view of which is reproduced herewith. The chief feature of these lamps is the use of Patent Bridge Core Carbons, by which the burning hours are doubled without increase of length, and without the use of a magazine arrangement with its possibility of break-down. The lamps are made in two patterns, for burning 20 and 36 hours respectively. The 36-hour type is specially suited for positions in docks, goods yards, &c., where the cost of trimming is a more important consideration than the somewhat large overall size of the lamp. In the accompanying illustration a noticeable feature is the special reflector fitted in the lower part of the globe. This improves very greatly the horizontal light distribution.



The "Jandus" Regenerative Arc Lamp.

The Jandus Arc Lamp and Electric Co., Ltd. (Hartham Road, Holloway, London, N.) have sent us a very well illustrated descriptive catalogue, dealing particularly with their well-known PATENT REGENERATIVE FLAME LAMP.* Following a detailed description of the lamp are candle-power and illumination curves and particulars of working costs, &c. One feature of interest is that 70 hours' life is claimed for a pair of carbons, and a specific consumption as low as 0.166 watts per mean hemispherical candle-power is said to be obtained. Attention is also called to the remarkable absence of shadows in this type of lamp; also to its penetration of fog, and other points which make it specially suitable for dock and harbour lighting. The accompanying illustration shows the external appearance of this lamp.

* See also *Illum. Eng.*, London, vol. i., p. 310, 1908.

Gas Fires and Wet Weather.

THE miserable weather which we have recently been experiencing must have stimulated the desire for a warm fireplace. The note which we have received from the **Gas Light and Coke Co.**, laying stress on the merits of gas fires, is, therefore, seasonable. It is pointed out that a gas fire is not a costly affair. Moreover, the simplicity and convenience with which it can be set going and turned off at any moment should lead people to use fires in their bedrooms with greater liberality, and thus avoid the risk of a chill entailed in coming out of a warm room into colder surroundings.

Forthcoming Lectures at the Royal Institution.

A CHRISTMAS Course of Juvenile Lectures on 'Sound, Musical and Non-Musical,' will be delivered by Prof. Silvanus P. Thompson at the Royal Institution. The first lecture will be on December 29th, at 3 o'clock, and the subsequent lectures on December 31st, January 3rd, 5th, 7th, and 10th, at the same hour.

Among other items we note that in March and April next Prof. Sir J. J. Thomson will deliver a course of lectures on 'Radiant Energy and Matter.'

Physical Society of London, Sixth Annual Exhibition.

THE annual exhibition of apparatus, under the auspices of the Physical Society, took place at the Imperial College of Science, S. Kensington, on Tuesday, December 20th, a very interesting collection of physical and optical instruments being got together. Among the photometrical devices shown the Holophane Lumeter, which has recently been described in this journal, was exhibited by Messrs. R. & J. Beck, Ltd.; Messrs. Everett, Edgcumbe & Co. also showed some photometers and apparatus for measuring illumination, including a new and small form of instrument termed the "Luxometer."

Among other apparatus of interest we note the microscope lamp and spectroscopes of Messrs. Beck & Co., the Fèry Spectrograph and demonstration of the Zeeman effect by Messrs. Adam Hilger, Ltd., and the ingenious speed-indicators and accelerometers due to Mr. W. R. Cooper and Mr. A. P. Trotter respectively. Messrs. Reynolds & Branson had on show some special lanterns and lantern microscopes, &c., and also a novel lamp for testing colour vision. There were also an interesting selection of electrical measuring instruments by The Cambridge Scientific Instrument Co., Messrs. Crompton & Co., Messrs. Elliott Bros., India Rubber, Gutta Percha and Telegraph Works, Ltd., Nalder Bros. & Thompson, and other firms; and meteorological apparatus by Mr. J. J. Hicks, Negretti & Zambra, and others.

Obituary.

The Late Mr. Gustav Byng.

It is with great regret that we record the death of Mr. Gustav Byng, on November 23rd, at the early age of fifty-five.

Mr. Byng had taken a great share in the development of the electrical industry for the last quarter of a century, and, in conjunction with Mr. Hirst, was one of the founders of the General Electrical Company, twenty-seven years ago. From that time onwards he witnessed the great development of this company to its present magnitude, and, in spite of ill-health, retained the position of Chairman, and applied to it his great financial abilities and organizing power almost to the last.

In addition to possessing great business ability, Mr. Byng, in his early days, was an indefatigable inventor, and it was doubtless to this combination of commercial aptitude and technical skill that his success was largely due.

His premature death will be keenly regretted by all concerned with the progress of the electrical engineering industry—an industry which he helped to build up from such humble beginnings.

CORRESPONDENCE.

Recent Progress in Gas Lighting and Advertisement.

DEAR SIR,—So far as I have noticed the discussion on this paper and the later communicated contributions from abroad, the claim of 70 candle-power per cubic foot consumed (high-pressure gas) put forth in the paper by the author has not been quite substantiated. All who know Mr. Goodenough recognize that he is not the man to make the statement he does without substantial evidence. The particulars of tests on this point would in my opinion be a very great help to all engineers interested in illumination, and particularly so to all gas engineers, amongst whom Mr. Goodenough holds so prominent a position. It may be that the obtaining of the results named by Mr. Goodenough are now matters of ancient history and that they have been for some time generally accepted. In such a case, I have simply exposed my ignorance.

The other point to which I would venture to call attention is the difficulty referred to by Mr. Goodenough of keeping out of his paper anything that would become "a vehicle for the advertisement of any particular make or makes of lamps or burners or mantles to the disadvantage of others." Mr. Goodenough's method of dealing with the matter has much to be said for it. There are, however, two sides to be considered. So soon as any particular street lighting is referred to at a meeting of this sort, all practical men are interested to know whose burners or lamps are used in the particular instance cited. I see no objection whatever to full particulars being given. The makers of the lamps and burners in question are quite entitled and surely welcome to the advertisement. A particular feature of good advertising is surely the removal of any apparent purpose or interest. Anything that bears the imprint of the advertiser has little value. Perhaps I may add that in my opinion the manufacturer of a rival lamp or burner is more likely to criticize his opponent's lamp fairly than any one else, because he would know what would happen were he to attempt to decry his rival's wares and to eulogise his own. We are all more interested in ourselves than in other people, but we should never be tolerated in any society if we were always demonstrating this fact. I trust there are others who will agree with me on this matter, as anything that tends to keep back useful information is detrimental to those interests which Mr. Goodenough and others have so much at heart. I am, &c.,

GEO. HELPS.

Nuneaton.

Consulting Engineers for the New Home of the Institution of Electrical Engineers.

IT has been pointed out to us that in the description of the installation at the New Home of the Institution of Electrical Engineers (London), published in our last number, no particulars were given as to the consulting engineers responsible. We understand that this work was undertaken by Messrs. H. W. Handcock and A. H. Dykes,, who have spared no pains to make the electrical details of the installation satisfactory.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

SPECIAL mention should first be made of the series of **Papers at the Convention of the Illuminating Engineering Society** in the United States; these are included at the end of this review in a separate list. As it is intended to deal with them more fully shortly, comment is postponed for the present.

A wide range of subjects is also dealt with in the various editorials in American journals. Subjects familiar through recent discussions of the Illuminating Engineering Society in this country, such as **Glare,** are among those treated, **Street lighting** still excites much discussion both in this country and the United States. One point insisted upon in the latter country is the need for a higher æsthetic standard. Irregular spacing of posts and crudeness of design are complained of in many cases. The suggested **Street lighting Specification** is noted with general interest. K. EDGCUMBE writes pointing out some defects in methods based on specifying candle-power at a few arbitrarily selected angles.

E. L. ELLIOTT (*Illum. Eng.*, N.Y., Dec.) severely criticizes the conditions of **illumination in the Congressional Library** in Washington. Its contents are very valuable, its architectural design is superb, but the lighting conditions are stated to be primitive and faulty. Unfortunately a radical change in this respect could not easily be carried out now without spoiling some of the decorations. Other articles in this journal describe lighting installations in textile mills, fixture design, and other matters; the editorial is largely devoted to the Convention.

Among articles on photometry mention should be made of a contribution by H. KRÜSS (*Zeitschr. f. Instrumentkunde,* Nov.) in which a device is described for enabling the Lummer-Brodhun photometer to be used for binocular vision.

In the *Zeitschrift für Beleuchtungswesen* for Nov. 30 a new instrument for testing and preserving a **Record of Colours** is described. It is based on the fact that with two Nicol prisms and a plate of quartz of specified thickness inserted between them certain definite colour-changes in the field of view can be introduced. It is claimed to be possible to reproduce the conditions with absolute exactitude and so always secure a certain tint of colour at will.

Other articles of a scientific nature deal with **Phosphorescence,** the **Effects of Light on Selenium,** the qualities of **Luminescent Gases,** &c.

ELECTRIC LIGHTING.

The majority of papers on record in this section deal with arc lamps. Thus J. SEAGER (*Elec. World,* N.Y., Dec. 1) contributes an illustrated article on the development and use of **Flame Arcs in Great Britain.** L. CROUCH (*Elec. Rev.*, Dec. 9) deals with the work of Righi, Mercanton, and others on **Three Phase Arclamps.** The principle adopted is to use a carbon attached to each phase and a fourth neutral carbon. Photographs showing the structure of the arc are given. The **Decorative Design of Arc-Lamp Cases** and accessories is dealt with briefly by H. PUDOR (*Z. f. B.*, Dec. 10). K. A. ALBRECHT (*Illum. Eng.*, N.Y., Dec.) contributes a short article on the **Ventilation of Arclamps,** in which he discusses such matters as the existing methods of avoiding the deposit of fumes on the globe. Special mention should also be made of an article in *The Electrical World* in which illustrations are given of a considerable number of designs of globes and standards in use in different countries.

As regards **Glowlamps** we may note a letter from C. H. SHARP on the subject of the experiments of Kinsloe (see last review), regarding the effect of varying waveform in an alternating supply on the life and efficiency of electric glow-lamps. Further particulars are wanted as to the conditions under which the lamps were tested for candle-power, the number of lamps studied, &c. H. MOSS writes to the *Electrical Review* deprecating lamps being furnished to consumers by electricity supply companies.

Finally we may note an article describing the external illumination of the new premises of the Denver Gas and Electricity Supply Co., U.S.A., which is described as the "best lighted building (externally) in the world."

GAS, OIL, AND ACETYLENE LIGHTING, &c.

A general paper on this subject by J. C. BRIGGS is reproduced in *The Journal of Gaslighting* (Dec. 13). Besides summarizing progress in gaslighting, the author deals briefly with several points in illumination, such as the avoidence of glare, distribution of light, and use of

shades and globes. Special reference is made to the hygienic aspects of lighting and the effects of ultra-violet rays.

G. HIMMEL (*J. f. G.*, Dec. 3) deals with **Railway Lighting by High-pressure Gas Lamps** on high masts. The posts are conveniently spaced 50 to 60 metres apart and are 7–8 metres high. Stress is laid on the advantage over electricity of being able to extinguish one or more mantles, leaving the rest burning, during quiet periods when so much light is not required. Figures for the costs are presented, it being maintained that the system is cheaper than electric light.

An interesting note is contributed by ZACHERT (*J. f. G.*, Dec. 3), on **Municipal Showrooms for Gas Appliances.** The idea is to enable contractors of good standing to utilize well-appointed showrooms for gas appliances, a charge of 5 per cent on the sales being levied to cover the cost of organization, &c

The Journal of Gaslighting gives particulars of a form of Mansfield burner, utilized in Calcutta, for which special advantages are claimed. For example, the burner is said to be very little affected by changes in pressure, and the nozzel can readily be adjusted to give a wide range of consumptions. The question of effect of pressure on illuminating power of burners &c., is also somewhat fully treated by N. MACBETH in the November number of the *Transactions* of the Illuminating Engineering Society (U.S.A.).

An article on oil-lamps by G. W. STEWART (*Phys. Rev.*, Nov.) calls for special notice. The author traces the connexion between density, viscosity and illuminating power of oils, the effect of alteration in the wick, height of flame, &c., and illustrates his points by a series of curves. Several important conclusions are drawn, one of them being that a relation can be established between viscosity and illuminating power, enabling the latter quantity to be predicted by viscosity tests of any sample of oil, with a probable error under 1½ per cent.

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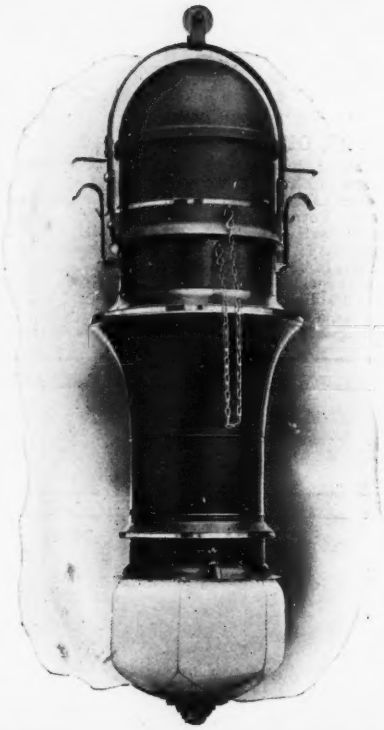
THE A.E.G. ELECTRICAL COMPANY OF SOUTH AFRICA. LIMITED.

FLAME ARC LAMPS.



METALLIC FILAMENT LAMPS.

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LOVEDAY STREET. CORNER OF ANDERSON ST. P.O.B. 1129
JOHANNESBURG.

AGENTS FOR THE ALLGEMEINE ELEKTRICITATS-GESELLSCHAFT, A.E.G. FOREIGN DEPT. (Berlin).

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

Library Illumination.

THE meeting of the Illuminating Engineering Society held on January 16th was devoted to the question of Library Lighting.

In accordance with the programme outlined by the President at the opening meeting, the Society, having devoted two evenings to a summary of recent progress in gas and electric lighting, now turns its attention to practical applications. The discussion on Library Lighting is to be followed by a similar discussion on school lighting, on February 16th, to be opened by Dr. J. Kerr, Medical Officer to the London County Council, and Dr. N. Bishop Harman.

The valued co-operation of the Library Association was invited at the last meeting and members of both societies were present and took part in the discussion.

Quite a number of highly debatable points were raised in the interesting papers presented by Mr. L. S. Jast, Mr. J. Duff Brown, and Mr. J. Darch. It soon became apparent that the subject could not be properly treated in a single evening, and at an early stage it was resolved to devote to it a second meeting, and to confine the discussion on the present occasion mainly to setting forth the views of librarian; at the next meeting, to be held on Tuesday, January 31st, the views of lighting engineers, contractors, and architects would find expression.

The discussion has done good in several ways. It has been of service in bringing home to the engineer certain aspects in Library Lighting which are of great consequence from the librarian's standpoint, for example, the distinction to be made in the lighting of different classes of libraries. The problems of properly illuminating reference libraries, reading rooms, and lending libraries are quite distinct; moreover, in individual cases the

routine of the library and the usual practice of the attendants, &c., should also be borne in mind in planning the illumination. Therefore before the method of lighting is decided upon consultation between the illuminating engineer and the librarian is most essential.

Again, the suggestions that came up in this discussion must have impressed many librarians with the progress that has been made in the scientific distribution of light and the importance of the appropriate choice of lamps, shades, and fixtures. In the account given of the visits to different London libraries, it was pointed out that in some cases the choice of shades and positions of lamps was injudicious, and that better results from the reader's standpoint could often be secured by quite simple modifications in the existing arrangements. Not infrequently an excessive amount of light was allowed to escape upwards and undergo absorption by dark surfaces and the brilliancy of the unshaded lamps was sometimes such as to embarass the eye.

Desirable Reading Illumination.

The complete table published in this number summarizing these results, and including data regarding the illumination on the reading tables in different libraries, should also be found interesting. It is to be observed that the intensity of the reading-illumination provided varies considerably; in the British Museum about 4 foot-candles is stated to be available, in the Patent Office as much as 10–20, in many public libraries only about 2. Naturally some latitude must be allowed in this connexion. It has, however, been very generally agreed in the past that 1 foot-candle is the absolute minimum under ordinary circumstances that can be tolerated, and most people, we fancy, would find this insufficient for many of the smaller types that prevail in the printed books of to-day. Probably, therefore, *at least* 2 foot-candles should be provided, and it is interesting that (excluding a few exceptional cases), this seems to be about the minimum in the libraries visited. On the other hand it is a fact that many people prefer an even stronger light, and it is understood that for very small detail, engineering drawings, &c., 5 foot-candles is none too much. A short time ago it might have been urged that the difficulty of verifying the actual illumination on tables limited the value of such figures as these. But now that the measurement of illumination has come to be regarded as such a simple and reliable process the difficulties in providing and maintaining a certain specified illumination on reading tables have been very largely smoothed away.

General v. *Local Illumination.*

Several speakers in the discussion seemed disposed to advocate general illumination on the ground of its presumed resemblance to daylight. But some discretion must be used in drawing conclusions from natural conditions, which differs at various times of the day, and with diverse climatic conditions, more than a superficial observer would suppose. Direct sunlight, for example, is a very different thing from the diffused illumination due to a cloudy sky, and natural like artificial illumination must be used wisely to be of service.

It should not, moreover, be too hastily assumed that a so-called general artificial illumination is the closest resemblance to daylight, nor that the conditions thus secured would be ideal even if the similarity were exact. In the case of daylight we have little choice, we must accept climatic conditions as they come. But in the case of artificial light we are dealing with exact factors under our control; scientific study and forethought are therefore needed to find out the ideal conditions for reading purposes.

Other questions discussed included the respective merits of local general

and combined systems of illumination. One point which may be emphasized in this connexion was the difficulty in drawing any hard and fast line in favour of any of these methods; the system selected must depend very largely on the nature of the library and its particular functions. For example stress was laid on the value of local table lamps, *plus* a subdued general illumination, in reference libraries for the use of students; but a cheerful general illumination might answer in the case of "reading rooms," where people drop in to scan the papers, &c.

Shelf and rack-lighting.

Another technical question of great interest to the illuminating engineer was the lighting of shelves and newspaper racks. It seemed to be generally felt that the present practice in these respects could be improved upon. Reference was made by Mr. Darch to the inconvenience of direct reflection into the eyes from shiny surfaces, and Mr. Dow's tests showed that the distribution of light was often very far indeed from uniform; possibly by the selection of proper shades and reflectors, a considerable improvement in this direction and also a marked economy might be achieved.

The exact details as to the best method of accomplishing this must be left to the discussion of experts, and we hope that some valuable suggestions in this direction may be forthcoming.

In conclusion it only remains to express appreciation of the co-operation of the Library Association in rendering this meeting a success, and to make special reference to the courtesy of those who granted facilities for tests of illumination to be made in the libraries under their charge.

We hope that this co-operation, thus commenced, will be persevered in, that suggestions brought forward at these meetings will be studied in the various libraries concerned, and that experiments will be made with a view to improving the existing conditions. We feel sure that the Illuminating Engineering Society will always be happy to encourage endeavours in this direction, and we may hope that intercourse between members of both bodies will do much to add to our present knowledge of what constitutes good library-lighting.

The Use of Coloured Light for Decorative Purposes.

We notice a very interesting description of a novel lighting installation devised by Mr. Bassett Jones, Jun., in the United States, and described in a recent paper before the American Illuminating Engineering Society. We hope to refer to this experiment in greater detail shortly.

The building in question was the Allegheny County Soldiers Memorial in Pittsburgh. Mr. Bassett Jones appears to have utilized the qualities of Mercury vapour lamps, the Moore Tube, and Flame arc lamps, &c., all of which yield light of characteristic and unusual tint, in conjunction with the natural decoration of the interior. We observe, for example, that in the banqueting hall the ceiling was composed of a mosaic of diffusing coloured glass above which flame arcs were placed, the idea being that the pronounced yellow tint and strong downward illumination was advantageous, and also that the occasional fluctuations in the light gave rise to a scintillating appearance resembling that of a jewelled pattern. Round the cornices immediately below the glass Moore tubes containing nitrogen gas, and yielding the characteristic pinkish tint, were run. Thus, while a luminous ceiling sparkling in many different colours was secured, the result and combined illumination below was said to be approximately white in character.

Another feature was the use of Mercury Vapour lamps placed in recesses in the wall between blue glass, and equipped with parabolic reflectors so as to illuminate the walls of the room with a soft blue tint.

Some of those who took part in the discussion of this paper likened the

system to the early highly coloured Byzantine scheme of decoration. Whatever views may be held on the desirability of such effects from the architectural and æsthetic standpoint, however, one may well suppose that the possibilities of coloured lights for spectacular purposes have not yet been fully exploited. Now that powerful lamps yielding light differing so greatly in colour are obtainable one may naturally expect something more remarkable than the crude use of naked glow lamps, characteristic of most of the schemes of festive decorations in the past.

Safety Regulations of the London County Council.

The series of recommendations issued by the London County Council during the last month, relating to the supervision of electric decorations, has received much attention in the electrical press, and the tone of discussion on the subject is distinctly favourable. The moment selected is opportune since electrical illuminations on an exceptional scale are expected to be a feature of the Coronation decorations next June and this preliminary notice should enable all reasonable precautions to be taken.

Electrical Engineers now recognize that recommendations of this nature are in the long run beneficial to the industry. On examination it would probably be found that a very large proportion of the cases in which unfavourable impressions have been formed regarding the safety of electric lighting were connected with spectacular effects. As we recently pointed out in connexion with illumination effects at exhibitions, the possibility of defective workmanship in such cases is increased, owing to the multitude of holders to be wired, the speed at which the work is carried out, and other factors. Yet the risk of fire can be reduced to small proportions if only timely precautions are taken and the work is properly executed with good material.

We notice that the London County Council do not undertake any responsibility in the matter, the recommendations being of a suggestive character, but they are none the less useful and we commend them to the notice of contractors and others concerned.

Town Planning.

The interesting Congress which took place a short time ago, dealing with "Town Planning," naturally aroused public interest. There is something very attractive in the possibility of designing a town on scientific and ideal lines, and providing adequate access of light and air, and orderly arrangement of buildings, in place of the chaotic conditions which often prevail at present.

There is, however, one side issue of the matter which we think ought not to be neglected, and which we hope will receive an increased amount of attention at future conferences of the kind, namely, public lighting. The appearance of streets during the daytime is affected very considerably by the nature of the lamp-posts and lamps installed, which are often anything but decorative objects. Seeing that the streets are used by many more people during the day time than during the night, this matter might well receive more attention, and an interesting precedent was recently set by the offer of a prize by the Royal Academy for an artistic design of a lamp-post.*

But in addition the appearance of the street by night, and the effectiveness of the artificial lighting ought not to be ignored in any broad discussion of town-planning. Hitherto this has been left almost entirely in the hands of engineers, and there have been few ready to point out the artistic possibilities of artificial lighting. We hope that in the future the term "City Beautiful" will be understood to denote not only a well designed city but also an adequately illuminated one. LEON GASTER.

* See *Illum. Eng.*, Lond., vol. iii., Nov, 1910, p. 687.

Review of Contents of this Issue.

THE first item in the technical section is a further article by MR. S. E. DOANE in which the need for **Standardizing the Dimensions of Incandescent Electric Lamps,** so as to maintain a definite relation between the position of the reflector and the filament, is insisted upon. Some dimensioned sketches of the standard types of lamp-holders adopted by the National Electric Lamp Association are shown, and also photographs of the gauges used to preserve constancy in the thread of the lamp-holder and the dimensions of the bulb (p. 69).

A note on page 72 refers to a method of **Artificially Illuminating Valuable Stained Glass** lent by Mr. Pierpoint Morgan to the South Kensington Museum. Incandescent tungsten filament lamps are used and reference is made to the difficulty in securing an exact resemblance to the colour of daylight; as it is by artificial light the colours of the glass are appreciably distorted.

Following this will be found a summary of the chief papers read at the **Fourth Annual Convention** of the **Illuminating Engineering Society** (United States), (p. 73).

An important report from the Committee of Nomenclature and Standards is presented, a table being prepared containing the suggested terms and symbols to be used to designate the chief photometric quantities.

There are also a number of papers dealing with the **Commercial Aspects of Illuminating Engineering,** which are summarized in this number, by MR. V. R. LANSINGH, MR. C. F. OEHLMANN, MR. J. F. GILCHRIST, and others. Particulars are given of the courses of instruction in illuminating engineering arranged for students, employees of electric supply companies, &c., and the importance to the salesman of a thorough knowledge of the qualities of the goods he is attempting to sell is insisted upon; salesmen of lighting appliances should therefore have a good practical knowledge of illuminating engineering.

Street Lighting is again dealt with in a paper by MR. P. S. MILLAR, the effect of "silhouetting" in the streets against bright backgrounds being pointed out; Mr. Millar insists upon the desirability of studying the surfaces in the street as well as the lamps used to illuminate them.

MR. H. S. WHITING describes **A New Street Lighting Fixture,** consisting in the combination of a prismatic globe with an opalescent one inserted inside; by this means, it is claimed, glare is reduced to a minimum, and a polar curve of light-distribution approaching very close to the ideal one for street lighting is obtained.

MR. N. MACBETH discusses the **Effects of a Pressure Rise on Flat-flame and Incandescent Burners,** showing how the polar curves of light distribution and efficiency are affected in different types.

Other papers deal with the more technical aspects of photometry. DR. H. E. IVES describes a series of experiments designed to compare **Equality of Brightness and Flicker Photometers.** The conclusion is reached that at high illuminations fair agreement is secured, but at low illuminations the two methods differ physiologically, and may not agree nearly so closely. DR. E. B. ROSA and E. C. CRITTENDEN summarize progress in flame-standards, and MR. J. G. FELTON and MR. E. J. BRADY describe the application of the **Thermopile in Photometry.** One more paper, by PROF. S. O. MAST, contains an interesting account of researches on

the sensitiveness to light of the lower organisms.

The section of the magazine devoted to the *Transactions* of the **Illuminating Engineering Society** contains a full account of the discussion on **Library Lighting** at the last meeting (see p. 81).

The papers presented by Mr. L. S. Jast (Hon. Secretary of the Library Association and Chief Librarian at the Croydon Public Libraries), Mr. J. Duff Brown (Chief Librarian at the Islington Public Libraries), and Mr. J. Darch, F.S.I., are reproduced in full.

MR. L. S. JAST expresses his approval of general lighting as compared with point-lighting, although the latter may sometimes be regarded as necessary in reference libraries. He then points out the importance of standardizing the arrangement of table-lamps and coming to agreement as to the desirable height, &c. In conclusion, he alludes to shelf-lighting as one of the most difficult problems the librarian has to encounter, and suggests several schemes by which better conditions of illumination than those at present realized might be secured.

MR. J. DUFF BROWN also refers to the vexed question of the relative merits of local and general lighting, and explains how, owing to the necessity of compromise between the architect and lighting engineer, he is rarely able to secure the exact conditions he prefers. One point in favour of general lighting as compared with local desk lights is the inconvenience of making alterations in the latter system, should it be desired subsequently to rearrange the benches. Among the requisites of good illumination are—absence of glare, avoidance of shadows, adaptability, and, of course, sufficient illumination on the exact spots required.

MR. J. DARCH lays stress on the desirability of avoiding anything in the nature of streaks and making full use of reflection from light-tinted surfaces. By means of diagrams he shows how shades can be arranged so that a minimum of light is lost and yet the eyes of readers are always screened from the direct rays. As regards local lamps, he favours the arrangement of table-lamps so that each reader can adjust the light to suit his own needs, and considers that a separate light for each person is preferable.

Following these papers will be found the account of the discussion in which MR. L. GASTER, MR. J. S. DOW, MR. L. C. WHARTON (British Museum Library), MR. H. V. HOPWOOD (Patent Office Library), MR. A. E. TWENTYMAN (Board of Education Library), MR. W. R. B. PRIDEAUX (Reform Club Library), MR. C. T. DAVIS (Wandsworth Public Libraries), MR. W. WHITAKER (Croydon Libraries Committee), MR. L. INKSTER (Battersea Public Libraries), and MR. F. PACEY (Westminster Public Libraries), took part. In conclusion, the President announced that the discussion would be adjourned till January 31st, when it was hoped that the standpoint of the engineer and the architect would be dealt with in greater detail.

Following this discussion will be found an article in which data regarding a number of London libraries are collected together and the installation in each case is critically examined. Measurements of the table and shelf-illumination in each case are presented, and views of some of the libraries visited are also shown.

At the conclusion of this section of the magazine two communicated contributions to the discussion of **Recent Progress in Electric Lighting**, by PROF. ELIHU THOMSON and MR. J. S. CODMAN, are printed. These are followed by the usual **Short Notes on Illuminating Engineering**, the **Trade Notes**, and the **Review of the Technical Press**.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Standardization of Electric Lamps and Lamp Parts in the United States.

By S. E. Doane.

(Chief Engineer of the National Electric Lamp Association, U.S.A.)

Incandescent electric lamps, reflectors, galleries and lamp holders, used in the United States, have been standardized to such an extent that scientific lighting installations can be made with the greatest facility. That such a condition benefits not only the various manufacturers concerned but the consumer as well, must be evident. A general standardization of parts was absolutely essential to the growth of the industry. Incandescent lamps must always be used in lamp holders and in most cases of interior lighting, they must be equipped with reflectors and galleries. It is obvious that in order to make it possible for the consumer to purchase his lamp holders from one manufacturer, his lamps from another, his reflectors and galleries from still another, with the assurance that the three or four separate parts will combine to give him the desired results, the manufacturers of the several parts must agree upon certain fundamental dimensions, and shapes of the bases, bulbs, lamp holders, reflectors, &c.

The lamp industry in the United States is a striking example of co-operation in the standardization of parts. The bulbs and bases have been standardized, and lamp holders, reflectors and galleries all fulfil certain requirements which enables them to be used interchangeably, and thus to accommodate any make of lamps of the size for which they were designed. Not many years ago there were several varieties of lamp bases in rather common use in that country. It was evident to the lamp manufacturers that this condition of affairs could be bettered, as the expense and inconvenience of keeping in stock several different varieties of bases was entirely unnecessary. Action was taken to promote the use of the Edison screw bases (which appeared to be the simplest and most satisfactory), and for some years adapters which allowed Edison screw-based lamps to be used in lamp holders designed for other types of bases were sold at cost or below. The lamp holder makers were induced to lend their aid to the movement and to discontinue the manufacture of lamp holders for other than Edison screw bases. As a result of this co-operation, the Edison screw base is now standard in the United States and a source of expense and confusion has been eliminated. Standard gauges for bases and for receptacle shells have been agreed upon by the lamp base and lamp-holder manufacturers to insure the maintenance of uniform dimensions of these parts. The accompanying illustration (Fig. 1) shows one form of base and lamp-holder gauge.

Lamp bulbs have also been standardized largely through the efforts of the lamp manufacturers. In the United States a number of glass

companies supply the lamp factories with practically all the bulbs used. Each lamp man was aware that he would undoubtedly obtain better service from the glass factory if the bulbs he used were of a standard design rather than of a special shape. This would greatly reduce the number of kinds of bulbs which would be demanded from the various glass

FIG. 1.

factories and would effect considerable economy, through the elimination of many special moulds.

After a good deal of discussion between the various manufacturers of lamps and of bulbs, standard bulb dimensions were adopted for the various sizes of lamps manufactured. In addition to the advantage to the lamp manufacturer obtained through such standardization, customers are assured that the lamp of any manufacturer will fit into any fixture and reflecting device designed for that particular size of unit. Standard steel templets as shown in an accompanying illustration (Fig. 2) have been agreed upon by both the lamp manufacturers and the bulb factories in order to maintain the bulbs to the specified dimensions.

It is very evident that to enable a reflector to be designed for a given style of lamp, the distance from the end

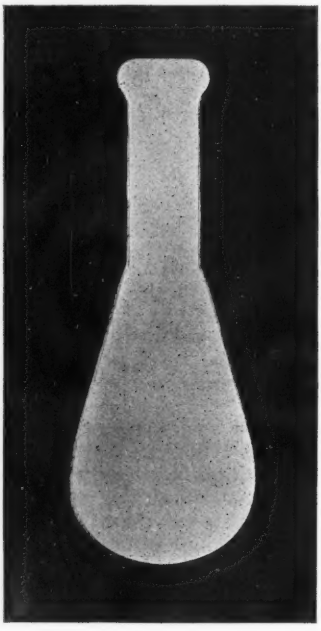


FIG. 2.

contact on the base of the lamp to the luminous centre or point from which the light may be considered as emanating, should be standardized. The position of the luminous centre of the lamp relative to the reflector is of vital importance since it affects the distribution of light from the unit. This distance has now been standardized for all styles of lamps which are used with reflectors.

Since the illuminating engineer has undertaken to scientifically utilize the

lamps and reflectors in producing the desired effect, he must know what to anticipate from certain combinations of lamps and reflectors, and he has a right to expect a certain uniformity in the goods which are put upon the

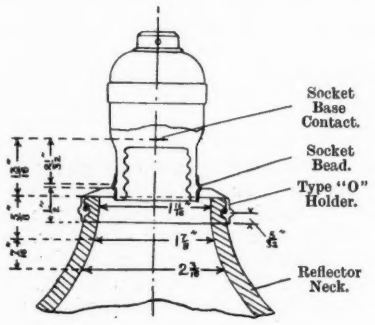


FIG. 3.

market. The importance of satisfying the foregoing requirement has been impressed upon both the manufacturers of the lamps and of the reflectors. As a result, there are certain specifications for the size of the reflector necks

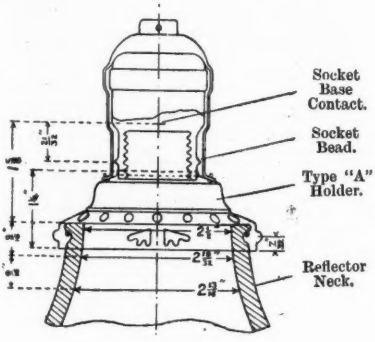


FIG. 4.

and again certain standard relations between these dimensions and those of the gallery used. In this way the position of the reflector relative to the lamp is always the same, as it must be to bring the luminous centre at the proper point. Some of the standard dimensions which apply to galleries and reflector necks are shown in the accompanying illustrations (Figs. 3, 4 and 5). By the adoption of such dimensions, the manufacturer of reflectors is assured that no lamps will be designed of a size suitable for use in a given reflector whose bulb dimensions and whose centre of light will be such that the combination will not give the best satisfaction.

In addition to the foregoing standardization of physical parts, definite wattage ratings have become standard for all types of incandescent

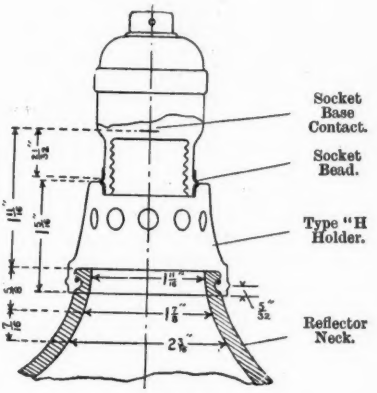


FIG. 5.

lamps, that is to say, the manufacturers make their lamps for such energy consumption as has been determined upon as being capable of the widest application, in commercial service. This has greatly simplified the design of lighting installations.

In general, it may be said that as the incandescent lamp and its accessory equipment has been standardized, it has become possible to use it as an illuminant more and more scientifically. Consequently many of the modern lighting installations in the United States are models of effectiveness.

Lighting Stained Glass.

By An Engineering Correspondent.

It is good to be a millionaire; it is best to be a public-spirited one.

The above remark is not the result of personal experience of such a position, but is written objectively by one of the general public who derive benefit therefrom.

It is well known that Mr. Pierpoint Morgan has spent much of his fortune on objects of art of many kinds, and that much of this valuable collection is lent to the nation for exhibition at South Kensington Museum. Amongst other things there is a quantity of stained glass, and that the *loan* is for no brief period is evidenced by the substantial arrangements made for its display.

In the gallery leading immediately from the Exhibition Road entrance five windows are appropriated for its display. The windows look towards the north—contrary to all ecclesiastical practice, where this is ever the last side to receive stained glass, the east being first chosen, and then the south and west, partly for sacerdotal reasons and partly to please the eye by coloured beams striking across the columns of the aisles when the sun shines full upon the window.

Round each window a wood bay has been built, standing two feet from the panes, and on this the various panels are mounted, backed by ground glass. By day, therefore, they are very well seen, but hitherto have presented a black, gloomy appearance at night when the arc lamps have been lighted and there has been no external light to pass through them.

The artificial illumination of transparent materials, without showing bright spots and general patchiness, is not always easy to arrange, but in this case it has been undertaken with good results.

To obtain uniform illumination the indirect method has been utilized, the lamps being fixed on battens, screwed to the dividing timbers between the glass panels, and throwing their light towards the windows. Over the windows large blinds of white holland are drawn which reflect sufficient of the light to show up the coloured glass as distinctly as by daylight. Except—there is always some fly in the ointment—in the matter of colour. The light at night is unfortunately much yellower than by day, a fact which is most noticeable in the plain panes with which spaces are filled in, which, by day a greenish grey, are distinctly orange at night.

Four of the bays are 10 ft. wide by 9 ft. high, the centre one being somewhat narrower, but having coloured panels in the two ends as well as in the front. The lamps used are 40 watt metallic-filament incandescents, and the numbers of these per window vary from twelve to eighteen according to the density and area of the glass to be shown.

To keep the lamps as snug to the front as possible, short angle-brackets are used. The bright lamp is then screened from observation by fixing two diverging fillets of uralite on the sides of the batten, so that the lamps lie in a sort of trough, these being arranged both vertically and horizontally as required in each particular case.

It will be seen that when the blinds are drawn up there is no interference with the day lighting.

For such "special" lighting the current consumption must, necessarily, be rather high, but the cost of this, in comparison with the value of the exhibits, is a mere bagatelle and the result will, it is hoped, provide much pleasure and some profit to those who visit the Museum in the short, dark days of winter. V. A. L.

The Fourth Annual Convention of the Illuminating Engineering Society in the United States.

(Held in Baltimore, Oct. 24th and 25th, 1910.)

THE complete text of the papers presented at the fourth annual convention of the Illuminating Engineering Society in the United States is now available in the *Transactions*, and we take the opportunity of drawing attention to some of the most interesting points raised therein. The final list of these papers was published in our last number (p. 60), and we have already referred to the series of lectures at the Johns Hopkins University which followed the Convention, and which, we understand, are to be published in volume form shortly.

Nomenclature and Standards: Report of Sub-committee.

In presenting their scheme of symbols and nomenclature for photometric quantities the committee make it clear that these are intended to be only provisional; and comment is invited on these preliminary suggestions. In addition to such familiar terms as "light," "luminous intensity," "mean spherical intensity," "spherical reduction factor," and "international candle," there are several less well-known terms suggested and defined. We note, for example, the definition of "specific intensity" as the apparent luminous intensity of a body per unit area, expressed in candles per square cm. By "specific radiation" is meant the total luminous flux per unit area expressed in lumens (or "millilumens") per square centimetre. The proposed names and symbols of these quantities are indicated in the table on next page.

In the discussion Dr. E. B. Rosa suggested that the views of European authorities on these terms should be invited, and Dr. Hyde explained that the list was only regarded as suggestive, and that comment would be welcome. Dr. Sharp added that the co-operation of the British Illuminating Engineering Society in preparing an acceptable list of terms and symbols would be highly valued. Mr. McAllister deprecated the use of the letters "E" and "I" in the connexion indicated, since these letters were already used very frequently to denote E.M.F. and Current. Mr. Stickney suggested that "specific consumption" as applied to electric and gas sources should be included in the list of terms defined, and Mr. E. L. Elliott advocated that the letter "J" should replace "I," as the former was commonly used in this significance in Germany. The question of the desirability of adhering exclusively to the metric system and discarding such terms as foot-candles was also discussed, Dr. Sharp explaining that for the present they had adopted British measures only in the case of quantities of British origin; he added that the expression foot-candles was clearly to be preferred to candle-feet. In dealing with the term "lux" attention was drawn to the discrepancy between the use of this word in the senses of Hefner-meter and bougie-metre respectively.

Illuminating Engineering, the Manufacturer and the Central Station.

Quite a number of papers were presented dealing with the value of illuminating engineering to the manufacturer of illuminating apparatus and the central station. An interesting account was given of the illuminating engineering department of the Denver Gas and Electric Supply Co. by Mr. Oehlmann. It may be noted that the author is not satisfied as to the value of sets of booths comparing the merits of different systems of lighting, arguing that the actual conditions existing in certain well-lighted shops, or in the streets, present better object lessons to consumers. In the showroom an at-

tempt is made to interest callers in the qualities of shades, lamps, &c., by explaining the principles on which they are constructed, and this method is said to give very good results. The author's ideas as to the treatment of consumers are very liberal. He rather welcomes a complaint, seeing in it an opportunity to improve the existing illumination, and, by contrast, convert the customer from a grumbler into an enthusiast. As a rule it is not the amount of money paid for the lighting that interests him so much as the effect. "When the illuminating engineering department, by a rearrangement of the old system, or by a new system, gives him three times as much illumination as before, the consumer is glad to pay the bill; the illuminating engineering department has "held the business." This last term "Hold the business" seems to be the key-note of the method employed.

It is to be noted that special efforts are made to secure remunerative night-load. Billboard lighting by flame arcs, porch-lighting, sign, and all-night window lighting are eagerly catered for, and special terms allowed. A record is kept of all new buildings in course of erection, and cards are sent to all, offering services, as soon as any interior is ready for wiring.

A special feature is the education of employees of the company, every one of whom is given the opportunity to join an illuminating engineering class during the autumn. In discussing this paper Prof. S. W. Ashe added some particulars of the courses of lectures arranged for employees in the lamp works at Harrison, N.J. Corps of college men are selected before leaving various universities and receive regular instruction, passing through the laboratories and works of the company so as to learn all connected with illuminating engineering. There are five distinct courses of instruction followed according to the branch of illuminating engineering which a man will enter. A special selection of specially trained men who are experts in such subjects as street, shop, sign, automobile lighting, &c., is also organized, and any problem that occurs is handed over to the specialist in the respective departments.

Other valuable papers by V. R. Lansingh, W. J. Serrill, and J. F. Gilchrist covered similar ground. We find the opinion expressed, (and it is strange that it has not been invariably accepted) that the salesman of illuminating apparatus must have a thorough knowledge of the qualities of the goods he is selling, must understand how to explain their merits by the aid of polar curves, and must be in a position to present exact data regarding their efficiency, durability, &c. In other words, although

Photometric magnitudes.		Name of unit.	Equation of definition.
1. Intensity of light or strength of luminous source.		(International) candle	$I = \frac{dF}{d\omega}$; $I_s = fI$
2. Luminous flux.		Lumen	$F = 4\pi I_s$; $F = I\omega$
3. Illumination	Specific flux or flux density.	$\frac{\text{Lumens}}{\text{cm}^2}$ or $\frac{\text{Millilumens}}{\text{cm}^2}$	$E = \frac{F_i}{S} = \frac{I}{r^2}$
4. Specific radiation	Brightness.	$\frac{\text{Lumens}}{\text{cm}^2}$	$R = \frac{F_e}{S} = mE$
5. Specific intensity	Brightness.	$\frac{\text{Candles}}{\text{cm}^2}$	$f = \frac{I}{S^1 \cos e}$
6. ——		Lumen-hours or lumen-seconds	$Q = FT$

International candle abbreviated to C.
International lumen abbreviated to L.
Hefner unit abbreviated to HK, as now used in Germany.
f is the spherical reduction factor of a light source.
ω is a solid angle $= \frac{\text{area on a sphere subtending the angle.}}{\text{square of radius.}}$

r is distance from light source in centimeters.
m is co-efficient of reflection or radiation, $(1 - m =$ absorption).
S is an area in square centimeters.
e is an angle of emission.
i is an angle of incidence.

1 S refers to surface seen from the point at which I is taken.

it may not be necessary for a salesman to know the details of methods by which such results are obtained he must have the actual finished data at his finger's ends. Moreover, the functions of the canvasser and the expert illuminating engineer are continually overlapping; a canvasser is being constantly confronted by practical problems. He is asked "What is wrong with the lighting of this interior, and what do you propose?" and though he may eventually call in the help of the technical expert, he must satisfy the prospective customer sufficiently to induce him to give the company a trial.

Another point insisted upon by Mr. Lansingh is the way in which the different classes of illuminating engineering business dovetail together so that makers of different classes of goods can assist each other. For example the sale of scientific shades and reflectors has been of immense assistance to electric incandescent lamp makers. Moreover, as Mr. Gilchrist added, the effect of all this energy in connexion with lighting matters is that the general standard of illumination is continually rising. People are making up their minds that good lighting is important and are therefore willing to spend more. Consequently the progress of the illuminating engineering movement has helped every one. Another feature of the movement, as Mr. Macbeth pointed out, is the spread of technical knowledge. He instanced the case of a maker of glassware who boasted that he had an organization that could sell any kind of crockery in existence. Yet within quite a short period he lost a considerable amount of money because the distribution of light from the shades was not satisfactory, and he could not present any satisfactory polar curves.

It may be added that the membership of the American society has now risen to 1,600; there are, however, some departments in which fuller representation is still desired. It is pointed out that there are 5,000 electrical central stations and 7,000 electrical contracting firms in the United States, each of which ought to be able to furnish one member.

New Factors in Street Lighting.

A paper by Mr. P. S. Millar, to which we have already made brief reference, emphasizes some newly recognized factors in street lighting. The author dwells upon the effect of "silhouetting," that is, the discernment of objects in black against a light background instead of by the aid of light thrown upon them. Naturally the surface of the street is an important item in producing this effect. Now Mr. Millar contends that silhouetting is the most general method of seeing things in the street, and that the success of this effect depends on the fact that the street surface is not truly "mat"; it really consists of an alternation of moderately diffusing material and small polished portions here and there which directly reflect the light. As a result of this objects are seen very largely by direct reflection from distant street lamps, the rays of which come at a very oblique angle.

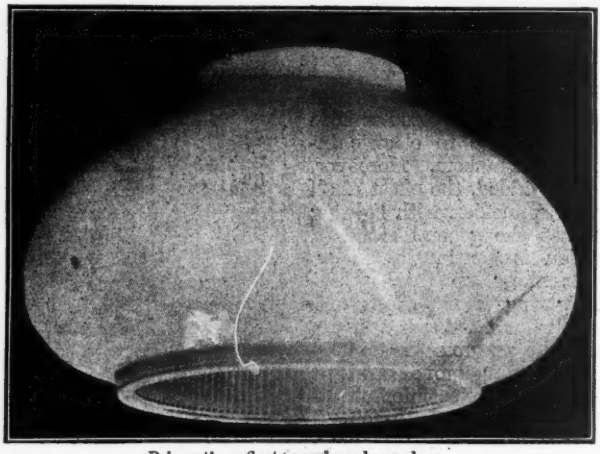
This effect compels reconsideration of the usually accepted view that uniformity of illumination on the roadway is very essential. Mr. Millar points out that it is possible to have very inferior uniformity in illumination, and yet to see clearly by means of this direct reflection from far away lamps. What is important is the surface of the roadway, and it is therefore desirable to use light tinted material for paving. Thus in some American cities the surface brightness of the roadway may be vastly more than in others, although the illumination is the same. The same thing may be said of the surface of buildings. Cities in which much coal is used suffer in this respect since the exteriors of all buildings soon become grimy, and the great part of the light thrown on them is therefore lost.

Another matter emphasized by Mr. Millar is the need for designing reflectors for street lamps so as to throw the light up and down the street rather than sideways. He points out, for example, that even supposing all the light is thrown downwards the percentage of the total flux of light reaching the pavement and roadway would, in the case of a street 80 ft. wide, only be

20 per cent; in certain streets the fraction would be even less. Seeing, therefore, the outside of most buildings has such a poor co-efficient of reflection, it seems necessary not only to throw the light downwards, but also to shape the reflector so that most of the light which would otherwise escape sideways is redirected along the street.

Mr. Millar agrees with other authorities in saying the most important item in street lighting is the avoidance of glare. He adds, however, that it is usually the more distant lights which are most liable to produce glare, because they fall in the direct line of vision. There are two chief ways of reducing the effect. Firstly, to avoid the exposure of lamps in the field of view, and secondly to raise the standard of illumination of surroundings in the street so that individual lamps are never seen against a very dark background. It is probable that this point will receive an increased amount of attention in the future.

A discussion ensued in which Mr. A. J. Sweet, Dr. C. H. Sharp, and others joined. Mr. Sweet did not agree that objects were seen mainly by silhouettes. This was certainly true sometimes, but in general one saw objects rather by the aid of their contrast with surroundings. The silhouette system was mainly in evidence in old-fashioned types of street lighting. Mr. Sweet also regarded uniformity of illumination as an exceedingly important matter. When as much as 10 watts per foot run was permitted for street lighting very perfect uniformity could be obtained, but even with 3 watts per foot run a diversity co-efficient of only 4 to 1 could be obtained. Dr. Sharp pointed out the tendency towards securing uniformity of illumination by having many units near together. While agreeing that excessive glare must be avoided, he thought it was necessary at present to concede something in this respect in order to get strong and even illumination. According to one definition direct reflection of the kind referred to by Mr. Millar was itself a source of glare.



Prismatic reflector and opal envelope.

A New Street Lighting Unit.

Another paper on a similar subject was that of Mr. H. S. Whiting, who described a scientifically designed street lighting unit. This consisted in a prismatic reflector, which was covered by an opal envelope; in the above illustration, the reflector is seen projecting below the opal shade. By this means glare was practically suppressed above an angle of 65 degrees with the vertical. More-

over, if the ratio between the distance of adjacent units and the height of the lamps was about 4 to 1, as recommended by Mr. Sweet, a polar curve of light distribution almost identical with the ideal one, calculated to secure perfect uniformity, could be obtained. The new reflector was therefore ideal from the standpoint of avoiding glare and producing perfect uniformity; also even when the ideal ratio of 4 to 1 referred to above could not be obtained it was still possible to secure very good results from this reflector.

In the discussion several interesting suggestions were made: for example, Mr. A. J. Marshall pointed out how the use of an opal shade of this kind rendered it possible to get pleasing colour effects by slightly tinting the glass. This would not seriously affect the efficiency. Mr. V. R. Lansingh also pointed out that the opal envelope served the purpose not only of reducing glare, but protecting the prisms from getting disfigured by dirt. The unit could also be designed so as to give an asymmetrical distribution, that is, to throw the light into the centre of the road rather than to the sides, &c.

Colour Photometry — Flicker and Equality of Brightness Methods compared.

A paper by Dr. H. E. Ives was devoted mainly to a comparison of luminosity curves in the spectrum obtained by the flicker and equality of brightness photometers. The author seems to have found that the flicker photometer was the more sensitive for heterochromatic work—at least for ordinary observers. In his experiments he utilized a Whitman disc rotating in front of the spectrum produced in a spectrometer. Two orders of illumination were used, namely, 10 and 250 meter candles. The illumination would, however, be about one-tenth of these values when an artificial pupil of 1 sq. mm. in area was used in front of the eye.

In the main these results seem to bear out those previously obtained in this country by Mr. Dow; for example, it is shown that the flicker photometer is less subject to the Purkinje effect than equality of brightness instruments. The author has also found that while the equality of brightness luminosity curve for the spectrum shifts towards the *blue* at lower illuminations the curve obtained by the flicker method shifts slightly towards the *red*. The most important fact brought out by this investigation is said to be that flicker and equality of brightness photometers agree much better at high illuminations than at low values. The paper contains charts of a large number of luminosity curves of different observers, diagrams of sensitiveness, &c., which bear out the above conclusions.

Progress in Flame Standards.

A paper by E. B. Rosa and E. C. Crittenden contains a useful summary of the chief past work on the subject of flame standards, and shows the trend of photometry towards even greater exactitude. Particulars are given of the comparison of different Hefner lamps showing that exceedingly good agreement can be obtained: thus one series of determinations shows a difference from the mean of only three parts in one thousand. Such differences as occur are believed to be due mainly to small inexactitudes in the dimensions of the tubes containing the wicks.

It would appear that the exactitude attained in reproducing the dimensions of the standard pentane lamp is less perfect. Cases are recorded of individual lamps differing by two or more per cent even when the conditions as regards fuel and atmosphere were identical. The American lamp also differs in several respects from the English one; for example it is stated to require twice as long before the steady condition of things is reached. The correct formula for correction for atmospheric conditions, however, seems to have been very well confirmed. In the discussion Dr. E. B. Rosa remarked on the fact that draughts might easily produce a change in candle-power. Mr. W. H. Gartley pointed out the fundamental differences between the manner in which sub-standards were applied when used for testing gas and electrical

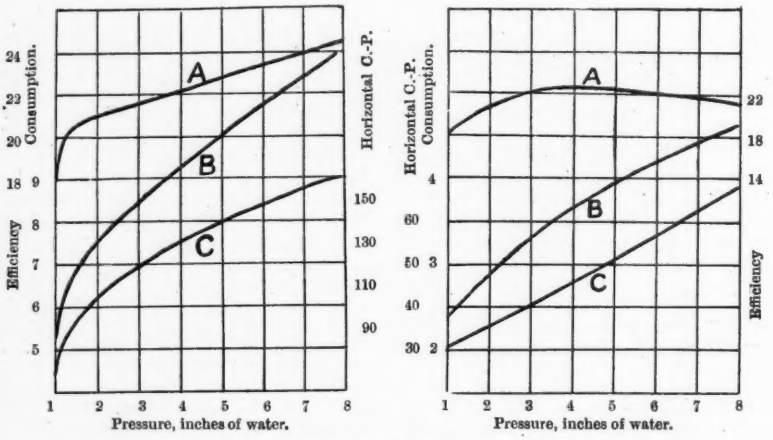
sources respectively. For example, atmospheric conditions are inevitably somewhat different when gas lamps are in actual use from what they are when the lamp is tested; therefore some latitude must be allowed. Mr. Crittenden mentioned that in using the Hefner it was customary to measure from the centre of the flame; this method was followed by the National Physical Laboratory in connexion with the Pentane lamp. He added that the nature of the wick used with the Hefner was not material so long as the dimensions of the tube are maintained. Dr. E. P. Hyde in summarizing the discussion remarked that there were several photometrical matters which required international conference. First of all there was the question of an international unit of light, which it was hoped, would eventually be accepted and used by the whole world, and next the possibility of securing an identical specification for the two flame standards. Among other matters which required to be dealt with were the regulation of the stages in passing from one colour to another in heterochromatic photometry and the nomenclature question.

The Relation between Pressure and Light of Gas Burners.

This paper, by Mr. N. Macbeth, was chiefly occupied with tabulated and graphic results of a large number of tests on ordinary open flame and incandescent burners. The author contends that insufficient attention has been paid in the past to the influence of pressure on the light of gas lamps.

For example, the two sets of curves shown in Fig. 1 are taken from a series of tests made by the author on upright mantle lamps. They indicate a marked difference in behaviour of the two lamps in question. In the first case, the candle-power increased very rapidly with the pressure, and a maximum efficiency was obtained at the highest pressure used, viz., 8 in.; in the second, on the other hand, the candle-power does not increase so rapidly, and the maximum efficiency occurs at about 4 in. pressure.

Similar tests carried out on inverted burners indicate a rapid increase of both candle-power and efficiency up to 2½ in. pressure, but above this value, the efficiency remains fairly constant, and the light output is not very greatly



Curve A = Efficiency.
FIG. 1. Curve B = Horizontal C.-P.
Curve C = Consumption.

increased; hence, if the pressure is not allowed to fall below the above value, satisfactory results should be obtained,

Fig. 2 shows the difference in the vertical distribution of light obtained from the same burner, using two different chimneys. This shows an increase of 14 per cent due to the use of a chimney with slightly larger air-holes. Another comparison made between a burner which had been given a "fitter's adjustment," *i.e.* the pressure required to give the maximum light was estimated by the eye, and a burner with the best possible adjustment, showed an increase of 10 per cent due to the careful regulation of pressure.

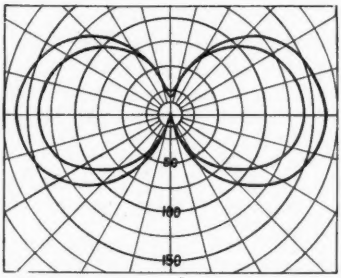


FIG. 2.—Difference in light distribution from upright burner, using two different chimneys.

A number of striking results were obtained for flat flame burners, very unexpected effects being sometimes produced by increase of pressure. In some cases an increase in pressure beyond a certain point even led to a reduced efficiency. The best burner was found to be one specially designed for use on high pressure, in which the efficiency at 8 in. pressure only fell off about 30 per cent, although the candle-power and consumption were more than doubled.

The Use of the Thermopile in Photometry.

In a former number of *The Illuminating Engineer** there appeared an article by W. Voege, in which he described a method of obtaining polar curves of light distribution in terms of the readings recorded from a thermopile and galvanometer. The simplicity of the method is an advantage, the thermopile being merely stationed in a series of positions so as to receive the radiation at different angles. This method involved the assumption of a definite relation between the total radiation from a source and the luminous intensity from that source, although an attempt was made to screen off the simple heat rays by interposing glass between the source of light and the thermopile.

A paper by Messrs. J. G. Felton and E. J. Brady indicates that this assumption should be made with caution, and may not always be justifiable. For example, it was found that with an electric incandescent lamp, the zonal curves of total radiation intensity and of luminous intensity agreed very satisfactorily, but when an incandescent gas lamp was used, with a green glass shade, the curves in the zones above and below the shade gave results differing considerably. It is clear that the heat rays would pass through the green glass comparatively easily, whilst the light rays would be largely absorbed. In another case it was found that an ordinary glass chimney on a gas burner caused a very appreciable difference between the zonal heat and light curves, due to the upper portion giving off heat, but no light. These examples are of interest as showing the limitations of the method of estimating light radiation as a certain fixed proportion of total radiation.

The Effect of Light on Lower Organisms.

Prof. S. O. Mast introduces this subject by pointing out the profound importance of light in its effect on life as a whole, and then takes as a special example two microscopic organisms, the Euglena and the Amoeba.

These organisms feed on certain chemical compounds which are only produced in the presence of light. Hence they depend for their very existence on keeping in the light, and this light must be of the proper intensity; if it is too strong it will be injurious, and if too weak the manufacture of food substance will not be carried out.

* Vol. i. p. 239.

If a large number of Euglenas are placed under the microscope, and mounted in a dark field which contains a light area of moderate intensity, they collect together in the light in the course of a few minutes, and it is observed that they orient and swim towards the light from all directions.

Moreover the illuminated area acts like a trap, for as soon as the organisms reach the edge on the way out and begin to pass into the shadow, the decrease of intensity in the illumination on the forward end produces a stimulus which causes them to stop and turn in another direction. When it is remembered that these minute organisms, of about 0·1 mm. in length, have no eyes, this regulation of their movements by the stimulus of light is of considerable interest. The author explains in detail by the aid of diagrams, how these movements are brought about, and points out that the organisisms are capable of moving from dim surroundings into brighter regions, or vice versa, according as the light in which they find themselves is of less or greater intensity than they require.

The Effect of Wave-Form on Incandescent Lamps.

SOME interesting results appear to have been obtained in some experiments by Prof. C. L. Kinsloe* on the life and efficiency of incandescent lamps as affected by the form of e.m.f. wave applied.

Tests were carried out on carbon, tantalum, and tungsten lamps, supplied from stock by manufacturers, and several of each kind were tested, so that the results may be taken as typical of what may be expected from lamps in ordinary use. One group of lamps was operated on a sinusoidal e.m.f. wave, whilst the other group was subjected to a peaked wave of the same effective value, and obtained from the same machine by the introduction of a series of reactance coils into the circuit. The effective value was 110 volts, the maximum in the first case being 155 volts, and for the peaked wave 174 volts.

All the lamps were found to work much more satisfactorily with the sine wave than with the peaked wave, a shorter life being invariably recorded in the latter case, as indicated in the following table.

The efficiency was also considerably less in all cases on the peaked wave, and diminished more rapidly with time. Carbon lamps on the peaked wave burnt out in about 800 hours. Moreover, before 500 hours had passed the candle-power and efficiency had fallen to values (12·5 and 4·3 respectively) which were not reached by the lamps working on a sine wave until they had been running for nearly 1,000 hours.

The tantalum lamps were the most seriously affected by the peaked wave, the average life being reduced by as much as 50 per cent.

Life of various Types of Lamps as affected by Wave-Form.

Type of Lamp.	Average Life in Hours.	
	Sine Wave.	Peaked Wave.
Carbon	943	860
Tantalum (25-watt)	375	75
Tantalum (40-watt)	1063	474
Tantalum (80-watt)	150	76
Tungsten (25-watt)	913	479
Tungsten (40-watt)	1904	1155
Tungsten (60-watt)	1319	767
Tungsten (100-watt)	1076	734

An examination of the filaments under the microscope showed that their structure was more irregular and broken up in the cases in which a peaked wave had been applied.

The general conclusion arrived at by the author is that the sine wave gives in every way more satisfactory results; it is interesting to note that the investigation is to be carried further to determine whether a flat-top wave would give even better values as regards life and efficiency.

* *Elec. World*, N.Y., Nov. 17, 1910, p. 1179.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Library Illumination.

(Proceedings at a meeting of the Illuminating Engineering Society, held in the House of the Royal Society of Arts (London), on Monday, January 16th, 1911.)

A MEETING of the Society was held on January 16th, THE PRESIDENT, Professor S. P. Thompson, D.Sc., F.R.S., being in the chair.

The minutes of the last meeting having been taken as read, the President called upon the Hon. Secretary to read the names of applicants for membership received since the last meeting and also to read again the names of those presented at the previous meeting on December 9th who would now formally be declared members of the Society.*

The President then recalled to those present that the object of this meeting was to discuss library-lighting. This was a matter which was of interest to quite a variety of experts, but especially so to those in charge of libraries. The Council of the Society, recognizing this, had invited the co-operation of the Library Association at this meeting. This was the first occasion on which the Society had had the pleasure of holding a common meeting with another professional body of great distinction, and the precedent established would doubtless be found very beneficial and would be followed in future meetings of the Society.

The President then proceeded to explain that three short papers were to be presented dealing, in a general manner, with the problem of library lighting, after which the Hon. Secretary would bring before the Society certain statistical data which had been collected, bearing on some of the chief libraries in London.

THE PRESIDENT then called in succession upon MR. L. S. JAST (Secretary of the Library Association and Chief Librarian of the Croydon Public Libraries), MR. J. DUFF BROWN (Chief Librarian of the Islington Public Libraries), and MR. J. DARCH, F.S.I., to read their papers in abstract. (These papers will be found *in extenso* on pages 83-92.)

Subsequently, at the invitation of the President, Mr. L. Gaster and Mr. J. S. Dow gave brief summaries of some tests that had been carried out in various libraries in London, dealing with the illumination of the tables and shelves, the current consumption per square foot of floor area, &c., and other details, and concluded with an expression of thanks to those librarians who had so kindly granted facilities for these data to be collected.

An interesting discussion then ensued in which MR. L. G. WHARTON (British Museum Library), MR. H. V. HOPWOOD (Patent Office Library), MR. A. E. TWENTYMAN (Board of Education Library), MR. W. R. B. PRIDEAUX (Reform Club Library), MR. R. W. CHAMBERS (University College Library), MR. C. T. DAVIS (Wandsworth Public Libraries), MR. W. WHITAKER (Croydon Public Libraries Committee), MR. L. INKSTER (Battersea Public Libraries),

* See *Illum. Eng.*, Lond., Jan. 1911, p. 28.

and Mr. F. Pacey (Westminster Public Libraries), took part.

The President then announced that the discussion would be resumed on Tuesday, January 31st, when an opportunity would be provided for the fuller expression of the views of the architect, the lighting engineer, and the contractor, all of whom were also actively interested in the problem of library lighting.

The meeting then terminated, and most of those present adjourned to the library, where tea and coffee were provided.

NEW MEMBERS OF THE SOCIETY.

The names of the applicants for membership, read out at the previous meeting on December 9th, were formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on January 16th:—

Members.

Dobson, S. T.	Chief Engineer, St. James and Pall Mall Electric Light Co., Joint Engineer, Central Electric Supply Co., 19, Carnaby Street, Golden Square, W.
Donnison, E. G.	Engineer, Holophane Ltd., Twycross, Surbiton.
Green, W.	St. James and Pall Mall Electric Light Co., 19, Carnaby Street, Golden Square, W.
Heygate, R. E.	Lamp Dept., General Electric Co., London.
Newton, E. B. B.	Civil Engineer and Borough Surveyor of Paddington, Town Hall, Paddington, W.
Rawlings, W. R.	Electrical Contracting Engineer, Past President of the Electrical Contractors' Association, 82, Gloucester Road, South Kensington, S.W.

* *Illum. Eng.*, Lond., January, 1911, p. 28.

Official Notice of Next Meeting.

The next meeting of the Illuminating Engineering Society will take place at the House of the Royal Society of Arts (John Street, Adelphi, London), on **Thursday, February 16th, 1911,** at 8 P.M., when a discussion on the subject of School Lighting will take place.

The discussion will be opened by two papers on the subject by **Dr. J. Kerr,** Medical Officer to the London County Council, and **Dr. N. Bishop Harman,** and the co-operation of medical officers of schools and others interested in this subject has been invited.

The Chair will be taken by **The President, Prof. S. P. Thompson, D.Sc., F.R.S.**

Applications for tickets should be made to the Hon. Secretary, Mr. L. Gaster, 32, Victoria Street, London, S.W.

(The account of the adjourned discussion on library lighting which took place on January 31st, will be published in the next number).

The Artificial Lighting of Libraries.

By J. Duff Brown, *Borough Librarian, Islington.*

(Paper read at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London), on Monday, January 16th, 1911, at 8 P.M.)

This short note will deal with certain problems and difficulties in the artificial lighting of libraries which have been observed by different librarians, and their solution can be discussed and perhaps suggested by the practical experts present at this meeting.

Like the ventilation of public buildings their lighting has always been a contentious subject, but I must confess, after reading much and observing more, that my own personal feeling is in favour of getting as near to nature as possible. For that reason, a plain open window, and a light as nearly like daylight as can be obtained, seem to me ideal conditions. In many cases, however, it appears to be impossible to get anything near to natural conditions, owing to the fads or mistakes of architects, and hot-water, ventilating, and electrical engineers. These specialists are nearly always in conflict, and as each has special requirements, every public building is the victim of a series of compromises and modifications which do not invariably yield satisfactory results. As regards libraries these conflicting factors affect the artificial lighting in a number of ways, and each department somewhat differently. I propose in dealing with these separate departments to assume that only electric light is contemplated, that being, I suppose, the most mobile, clean, and effective light for library purposes.

I believe it is quite possible to obtain a perfect artificial system of illumination in any building, provided the occupier is prepared to pay for it, but the human tendency to economize on the wrong things prevents this happy condition from being often obtained. Economy with regard to expenditure on lighting is compulsory as far as municipal libraries are concerned, owing to straitened means, and in a good number of cases this is the reason why many municipal library reading-rooms are badly lighted. Another reason is the fact that the lights have been arranged as symmetrically as possible to match the architect's ceiling-panelling, or other decorative whimsies, and the result is, in many cases, that while a pleasing design is obtained, it is only effective during daylight; because, as night advances, the room is only illuminated by certain points of light, generally in the wrong places.

To deal first with the Reference Department. The problem here is how to light reading-rooms arranged for different systems of administration, and fitted with alcove or ordinary wall shelving. The lighting for a reference library in which readers are allowed access to the shelves must be arranged so that the book shelves will be as well lighted as the reading tables, and it is necessary to light the books so that their titles can be easily read, and to avoid the shadows of the readers being cast over the shelves. This raises the question of local *versus* general lighting, on which considerable difference of opinion exists.

In Reference Departments where access to the books by readers is not permitted, the question of lighting the book cases or stacks is quite a minor point, and only the reading tables need be thoroughly well lighted. In general where readers are not allowed access to the shelves the books are arranged in stacks behind barriers, and not round the walls in alcove or other forms. The problem in the Reference Department then, is first how to illuminate reading tables effectively, whilst also in the case of Open Access book shelves, making the titles of the books and the classification guides perfectly clear to readers.

In News Rooms or General Reading Rooms the main problem is how to light newspapers spread out on sloping reading stands either arranged against the walls or standing across the room at right angles to the walls. If the lighting is arranged for each stand

independently it means that the fittings become fixtures, a disadvantage always associated with wiring which has to be conveyed along the floor and attached to tables or stands. For this reason my own preference is in favour of having the lights hanging from the ceiling independently of furniture, so as to obtain complete adjustability whenever required. There is hardly any library in existence which has not at some time re-arranged its fittings and furniture, and it is often difficult to make alterations without overhauling the whole of the lighting apparatus.

In Lending Departments arranged for Indicator charging, it is necessary to have the Indicator itself and the counter thoroughly well illuminated on both sides, and it has occurred to me on several occasions that a long tubular light arranged close to the Indicators on the upper margins, so as to illuminate downwards, would be an improvement on any overhead system which casts the shadow of the borrowers over the numbers. This method has been tried, I understand, in libraries where the readers are permitted direct access to the shelves, and it is claimed that the arrangement prevents shadows from being cast on the books. I doubt, however, if the lower shelves are as well lighted as the upper ones. Where readers are not permitted to have access to the book shelves the ordinary hanging lamps are quite sufficient, provided there is nothing in the construction of the book-cases to obstruct the light.

The lighting of other departments is very much the same as in the three main departments dealt with, and the only other point I propose to mention is the lighting of the exterior of the building, which, from the point of view of advertising the existence of a library, should be made more effective than it is in most cases. After nightfall, in a large city, the most conspicuous public buildings are theatres, music halls, and taverns, and that is so because some effort is made to illuminate them outside. Most public libraries, and particularly those which have no reading-rooms at the front, often look as dark and dull as if they were uninhabited.

The chief problems of library lighting may be summarized as follows :—

1. To light Reading-room tables so as to avoid glare in the eyes of readers.

2. To prevent the casting of strong single or multiple shadows of any kind.

3. To avoid fixing furniture or fittings in permanent positions ; and

4. To ensure the illumination of the room generally, as well as the tables.

5. In open access lending or reference libraries the illumination of the book shelves should be arranged so as to avoid as much as possible the shadows of readers falling on the books, and also to ensure the lighting of the lower shelves.

To obtain these various results it appears to me that, whatever kind of illumination is used, it is necessary in most cases to adopt general lighting, reinforced at all weak points by local lighting.

The Artificial Lighting of Libraries.

By L. Stanley Jast.

Honorary Secretary of the Library Association. Chief Librarian of the Croydon Public Libraries.

(Paper read at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London), on Monday, January 16th, 1911, at 8 P.M.)

There are really two problems of library lighting. The first is the problem of lighting rooms for purposes of reading and writing, which is of course in no way different from the lighting of banks, offices, and similar apartments. The second is the lighting of bookcases and of gangways between bookcases ; this is the specific library problem, and the one which is by far the most difficult of solution.

I will deal with the general problem first.

One may perhaps speak of two more or less distinct periods in the lighting of libraries. The earlier period is marked by general lighting, usually obtained from lights or clusters depending from the ceiling or roof, with little or no point or local lighting. The results have rarely been happy. The architect has only too often arranged his lights according to purely decorative or architectural considerations, without paying any regard to the position of readers and tables. Hence it was no uncommon thing to see a roof or the passages between tables brilliantly lit, while the tables themselves were left in comparative obscurity. The results obtained by this happy-go-lucky system —by no means unknown even now— were worse as a rule when the source of illumination was the electric lamp.

The absolute necessity of obtaining light where it was wanted, whether there was any light anywhere else or not, brought about the second and present period, in which the emphasis seems to be laid on point lighting, with a comparative neglect of efficient general lighting.

I presume there can be no question as to the undesirability of point lighting in itself, more especially when it is the primary source of illumination, and not subordinated to a scheme of general lighting.

That being so, it appears to me that point lighting should be avoided wherever possible, and I contend that it should and could have been avoided in many recent examples of library lighting. One rarely sees in this connexion proper treatment of the walls of the apartment, so as to provide good reflecting surfaces, and so aiding not only in the thorough diffusion of the light, but effecting a considerable economy in the direct illuminating power. Excellent results have been attained in one magazine room by suspending unshaded electric incandescent lamps about one foot below the ceiling, and colouring the walls cream; there are no table lights at all.

Where, as is the case in many reference libraries, the walls are utilized for shelving books, no reflecting surface other than the ceiling is of course available; even then, however, if the bookcases are not carried up to the full height of the walls, it would probably be worth while to utilize a space above the cases in this way.

It is clear, however, that in many, perhaps in most, reference libraries point lighting for the reading tables or desks will be a necessary evil. The question then arises as to whether suspended lights over, or standards on the tables are to be preferred. If a standard is chosen, what is the best height above the table and design of standard, and, more important still, what is the best form of shade?

The only scientifically constructed shade is, I presume, the Holophane; my objection to it for table-lamps is that you have a bright light immediately above the eyes, not of course so accentuated as in the case of the unshaded lamp, but sufficiently annoying nevertheless. After trying myself several varieties of shade, I prefer on the whole the ordinary cone-shaped opal shade, as deep as it is possible to get it, so that the reader seated at the table is unable in any ordinary position to see any part of the lamp itself.

I come now to the special problem of library lighting, which appears to be sufficiently difficult to deserve all the attention and skill which the illuminating engineer can bring to its consideration.

The problem is briefly that of illuminating a narrow gangway between bookcases, of an average width of from 3 ft. to 4 ft., and at the same time lighting two vertical walls of books, covering an average width of say 9 ft. 6 in. to 10 ft., with an average height from the floor of about 8 ft. I do not remember to have seen an absolutely satisfactory solution of this problem, and I am inclined to doubt if such a solution is possible. On the whole I believe that the best average results are achieved by lights over the centre of the gangway.

The alternative is to employ lights on the cases. In our own library we have fitted the tubolite (formerly lino-

lite) lamps on the cornices of the cases, so arranged that the lamp on one case lights the books on the opposite case. The result is fairly satisfactory, the main objection being that the lamp is fully visible to the eyes when examining the upper portion of the case. Fortunately one does not expect readers to do more at a case than read the titles of the books required; while the absence of fittings projecting from the tops of the cases is a distinct æsthetic gain.

I do not know if any library has attempted to light bookcases by what is known as pattern 21 of the tubolite, hung from a fitting projecting in front of the case; this pattern, I am informed, is used for lighting pictures.

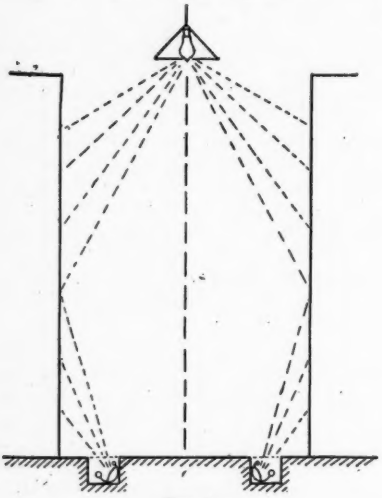


FIG. 1.

It has been suggested to me that it might be practicable to carry up the cases so as to provide a certain amount of reflecting surface to aid in the diffusion of the light.

Finally, in regard to this problem, I have a suggestion to make, which seems to promise better results than any yet attained. The difficulty is to light properly the lower half of the case. My idea is to do this *from below*, as one lights the lower half of a stage by footlights. I would cut a longitudinal trough in the floor, parallel to and at a suitable distance from the case, cover it with glass of the necessary thickness, and in this trough I would place my lamps, with reflectors so arranged that the light would be thrown directly on to the case (see Fig. 1). To prevent any light reaching the reader from below, the trough might have an opaque lip on the edge furthest from the case. For economical and other reasons I would have these lamps to be switched on by readers as required. A bar running the length of the trough and projecting slightly above the floor level might be fixed in such a manner that when pressed by the foot the light would come on automatically, going off as soon as the foot is removed. Instead of the trough, the lamps might be hidden in the step which is found in some libraries at the bottom of the case. I illustrate this arrangement in Fig. 2, with an alternative of lighting the upper part of the case by tubolite in place of the centre drop.

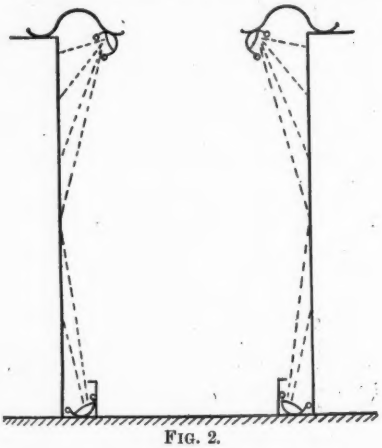


FIG. 2.

By way of conclusion to this short, and, I am afraid, very inadequate paper, I will state the points which occur to me as those on which the opinion of illuminating experts would be valuable.

1. Is it desirable to do away with point lighting as far as possible, relying wholly or mainly on well diffused general lighting?

2. How far should wall surfaces be employed as an agent of diffusion ?

3. If tables are lighted locally, which is the most satisfactory form of shade ?

4. What is the best solution of the specific library problem of lighting bookcases, especially when these are divided by narrow gangways ?

The Artificial Lighting of Public Libraries.

By John Darch, F.S.I.

(Paper read at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London), on Monday, January 16th, 1911, at 8 P.M.)

In dealing with the lighting of public libraries I propose to take the municipal or popular library as the typical subject for consideration, although my remarks would be equally applicable to either of the various special or other libraries—the principles involved being in all cases the same—the details varying from those of the municipal library only so far as necessary to meet special requirements.

The more one thinks upon the subject the stronger becomes the conviction of the need for a complete and perfect system of illumination in every public library. Continuous reading is a great strain and renders the eyes very sensitive to perverse influences and therefore every possible provision should be made for the needs and comfort of the reader. But what are the facts ? There is not to my knowledge a library in London, if in England, however luxurious it may be in other respects, that is provided with satisfactory lighting arrangements, most of them being illuminated in a manner that would answer equally well for a warehouse or a restaurant. We all know and approve the plea for public libraries—the age demands them—but where is the wisdom in providing books without adequate and safe means of reading them. I have often handled and regretfully laid aside a tempting book knowing that I dare not read it in the light provided. What good is that book to me ? Enthusiasm may struggle against physical difficulties, as it commonly does, and ophthalmic injury is the usual result.

Our experiences of library building and fitting leads one to the conclusion that there is no alternative but legislation. If an Act of Parliament has been found necessary for factory lighting it is clearly no less necessary for the public library, the owners or controllers of which should be compelled to provide sufficient and satisfactory illumination or to close the library as a public nuisance.

I am speaking to librarians who are always beset by the difficulties of finance, and who look upon the ideal with the sad feeling that it is also the unattainable, and therefore not within the realms of discussion. I wish to maintain that the ideal *must* be the goal, and that in matters of public health it is false economy to stop short of it. Let us be as frugal and judicious as possible in our expenditure upon the less essential features, but not in this.

General Lighting.—The first principle of library lighting to be emphasized is that there must be a general lighting of the reading-rooms distinct from and in addition to the local lighting of the desks, &c. To rely upon general lighting alone, as is done in perhaps the majority of libraries, is a great mistake, being both a useless waste of light and a failure as far as reading utility is concerned.

For general lighting it is not necessary to have more candle-power than will be required to see about the room ; 0·75 foot-candles should be ample, and it should be soft and well diffused ; which it would be if the light were derived largely from the illuminated walls and ceilings.

If the room is lofty there is nothing better or more economical than an arc lamp, or, better still, a regenerative

gas or Wenham ventilating lamp provided they are well above the sight line. Whatever lamps are used they should be placed only just far enough below the ceiling to avoid dark shadow contrasts thereon, and to admit of its being well illuminated.

The worst general lighting is that which is most common; yet, which has been specially recommended by a library expert, viz., plain opal shade pendants at equal distances apart, and about 8 ft. 6 in. from the floor. In this arrangement the ceilings and upper half of the walls are placed in gloom, and yet, go where you will, you cannot avoid the glare of one or more of the lights: such an arrangement is at the same time wasteful of light and inadequate for reading. I disapprove of downward or other reflectors in general lighting, particularly the polished kind which reflects in spots and streaks; a room is better lit when ceilings and walls are permitted to do the reflecting.

For low ceilings, the lamps should be placed as high as the proper illumination of the ceiling will admit, and the direct light kept from the eyes by means of opaque or semi-opaque screens, in which case the lamps should not be enclosed in obscured glass. The form of these screens will depend upon circumstances, but Fig. 1 is a suggestion for an average case, and may cover an arc-lamp, filament lamp, incandescent gas, or a regenerative burner. By this means good general illumination may be obtained without the lights being seen. Indirect lighting is also specially suited to low ceilings, in which inverted arc-lamps may be used; or ordinary bracket lights screened from the eye level, yet arranged to illuminate the ceiling and walls, and which will give a pleasing and sufficient general light. This method of treatment is more fully explained under the head of the 'Art of Shading' in *The Illuminating Engineer* of February and March, 1909.

Reading Desks or Tables.—For practical purposes the most important light for the reader is, and must be, the local reading lamp. No general lighting will meet the case; for it would involve a wasteful and intolerable blaze in order to obtain sufficient light to read by.

One point that I wish to make is the importance of providing *a separate light for each reader*. Every librarian will at once cry out about the luxury of it and the cost. As to the luxury let it be remembered that the necessities of to-day were always the luxuries of yesterday, and the separate light will be the necessity of to-morrow. As to the cost I will presently show that it is more economical. The principle has already been adopted in the libraries of several clubs; in which a shade is used something akin to those made for theatre orchestras, although a dense green ordinary cone shade, with the lamp well recessed, would be equally

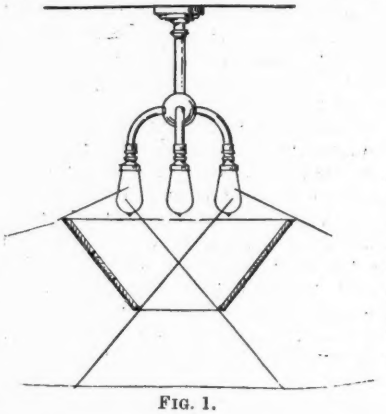


Fig. 1.

satisfactory, and the position of both lamp and reader be pleasantly seen. There are other simple forms of shades to meet special needs, but in all cases the depth of the shades must be adjusted to cover the eye in sitting or standing. At the British Museum there is one reading lamp between two readers: this means that for one reader the lamp is on the wrong side, while it often produces an unpleasant jostling of heads and elbows, and a feeling in the heart of each that the other is trespassing.

Librarians have pointed out that when readers are within control of the lamps they frequently and selfishly endeavour to monopolize more than their share of the light to the discomposure of others; whereas the real

interpretation should be that the reader absolutely needs more light. For myself, nothing produces aching eyes more readily than an insufficiency of light.

The tendency of the librarian is to treat every reader alike. Well, that sounds fair enough; but in reality, it is very unfair, and is thrusting unnecessary hardship upon all classes of readers. Men's eyes differ: some experience trouble for want of light, others from the glare of excess; sometimes a reader gets bright white paper and large type, and he needs a quiet light; later he may have dark paper, small type, or an indistinct drawing, and will need a strong light, while

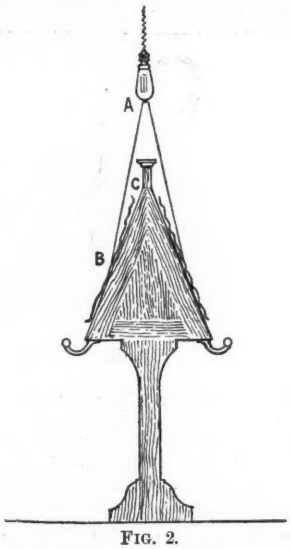


FIG. 2.

some paper needs a careful adjustment of the incidence of light—all of which means that no two readers need the same light, and leads me to my next essential point, viz., that *every reading lamp should be adjustable and under the control of the reader*. When at home do we not find it essential to be able to adjust the light to our work: the need must be the same in a library. There are a number of suitable devices for movable lamps already on the market, and a little ingenuity might add to their suitability. Broadly they are of two kinds, those which move up and down only, and those which move in several directions; either may be standards, brackets, or pendants. The lamp should reach down to about 1 ft. from the desk and rise to about 2 ft. 6 in.

With regard to the necessary intensity: a clerk writing on white paper may do very well with 1 foot-candle, as the eye-strain in writing is not nearly so great as for reading, where at least 3 foot-candles would be required to meet the same effort. The amount of illumination on a table or desk should, at a distance of 2 ft. 6 in. be about 2 foot-candles which, when lowered, would be increasable at the reader's will to about 12 foot-candles.

I have already referred to the librarians' ever-present bogey of expenditure. I now propose to lay that terror by suggesting a considerable saving in current expenditure without depriving the reader of the "luxuries" I have advocated; and that is my third point, viz., that *readers should be left to switch on and off their own lights*.—Some librarians say that the public could not be trusted to deal with moveable lamps and switching arrangements. It is a slowly dying prejudice. Public enterprise has over and over again shewn that it pays to put confidence in the people, more particularly when he is an intelligent reader. I have been in the South Kensington library when every light has been going with scarcely a reader, I have seen nearly all the Patent Office tables empty, I have seen but five readers in both reference library and news room of the Guildhall, but in each case all the lights were fully going, as though they were being used. Is this economy, and what has the tax-payer to say about it? If, on the other hand, my proposal was adopted, the reader would walk into a quietly lit room, select his table and switch on the light which would be concentrated on his book. When he leaves his desk, it should be, and would become a matter of ordinary good behaviour for him to switch off his light; but should any one fail to do so, the assistants are always on the spot, and could easily remedy the omission.

There would be, of course, a little extra first cost—£100 should cover it in any library—and if that is objected to, let that extra cost be saved out of the architectural ornament, for much as I approve of a worthy building for a worthy purpose, the book and facilities for reading it are the *sine quâ non* of a library.

All this implies that each reader should have an apportioned space or desk. It is done so at the British Museum with a width of 4 ft. 3 in., but 3 ft. 6 in. should be ample for simple reading.

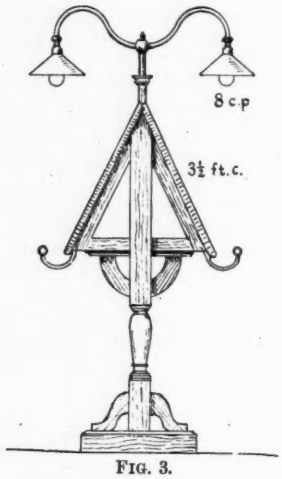


FIG. 3.

NEWS STANDS.—Much that I have said will apply with equal force to the news room.

In the majority of libraries, although there is often a brave show of lights, the stands are badly and unequally lit. The rule appears to be to distribute plain pendants throughout the room, regardless of the positions of the stands or desks and consequently the amount of light in foot-candles reaching the newspaper is often ridiculously small. At the Guildhall and at other libraries the reader is able to admire the form of his own shadow in front of him, and has to read through the gloom of it. At Wandsworth, Kensington, and many other places a lamp is suspended directly over the stand—the very worst position—for by reason of the extremely oblique direction of the rays the illumination is very small, and reading is rendered still more difficult in consequence of the puckerings of the paper. Fig. 2 illustrates this. A is a 30 c.-p. lamp, the downward radiation of which is, however, only 18 c.-p. The lamp is 3 ft. from the centre of the desk at B, and the angle of incidence A B C is 10°; therefore the illumination of the slope is $\frac{18 \sin a}{3^2} = 0{\cdot}34$ foot-candles. What a miserable result from a 30 c.-p. lamp, and what a waste of light!

The best arrangement I have seen is at Cripplegate. The newspaper stands are 8 ft. long, for two newspapers a side, and 2 ft. from the end of each—

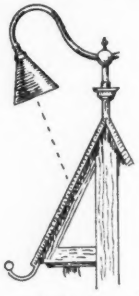


FIG. 4.

that is in the centre of each newspaper—is a bracket lamp at about the level of the top of the stand, and projecting 15 in. (see Fig. 3). A light of about 3½ foot-candles is thereby obtained from only an 8 c.-p. lamp. Here you have a splendid light for a small expenditure of current, and independent of the crumpled paper. On the other hand, the lamps are painfully visible whichever way you turn: a simple improvement would have been to have had deeper shades and to have them directed towards the newspapers, as in Fig. 4.

I had hoped to deal with the lighting of book cases, racks, indicators, and other important features of the municipal library, but time and space forbid.

PAPER GLOSS.—I feel that I ought not to close my paper without reference to an element in lighting that has not received the attention it deserves, and

yet is one of great importance to the constant reader. I refer to paper gloss. We all know the unpleasant effect of the reflection of a bright sky from the surface of water or from wet streets, and are generally in haste to remove ourselves from it. Precisely the same

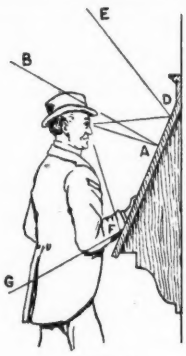


FIG. 5.

thing happens, but in a lesser degree, with paper. I am not aware of any paper—and I will not even except blotting paper—that has not more or less of a distinct gloss when viewed in the angle of reflection from any bright light—and it usually happens that the ink is also glossy—consequently, not only is a greater effort required to distinguish details, but the excess of light and heat which may be unnoticed at first becomes eminently irritating and injurious in the course of a protracted sitting. This can easily be avoided and it certainly should enter into the calculations of the illuminating engineer.

Let us take a news stand, Fig. 5. If the lamp were at B the incident light at A would reflect into the readers eyes; in like manner, if the lamp happened to be placed higher or lower, then the glare would be seen at correspondingly higher or lower points on the stand. It follows, therefore, that to avoid glare from any part of a newspaper the lamp must be placed somewhere on the line D E.

With regard to the reading tables. The tops of these are usualy level, but many are provided with a slight slope. I have often found that the gloss of a page makes it impossible to read it unless the book is carefully tilted, and when there are the reflections of two or more lights it often requires considerable manipulation to avoid it. In Fig. 6 A is a lamp, AB and AB′ the angles of incidence, BC and B′C′ those of reflection. On the left side I show a flat table where the reflection enters the reader's eyes. On the reverse side I show a sloping table top, in which the reflected ray from the corresponding spot is harmless. This does not mean

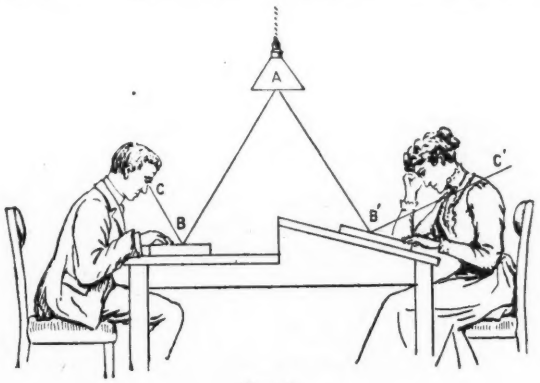


FIG. 6.

that sloping tables are better than flat ones, because an altered position of the lamp may just reverse the result; but it does mean that the reader should be spared the possibility of such an annoyance, and this can be done not only by each reader having an appor-

tioned space, but that in that space there should be a lifting portion on a rack by which a book can be adjusted to any angle.

I have dealt only with the leading points; but I think that what I have said is sufficient to show that whatever may be the need for free access to our great literature, there exists an equal or greater need for the very best facilities for the study of it, more particularly in view of the increasing degeneration of the eyesight of the modern student, and I see no hope of universal reform until the law steps in to make it compulsory.

Discussion.

Mr. L. Gaster emphasized the view that good library lighting was only to be secured by timely co-operation between the architect, the librarian, and the lighting engineer. For example, in the United States, the first President of the Illuminating Engineering Society had co-operated with the architects at an early stage in the planning of the Carnegie libraries in New York, and the results had been very satisfactory. He had before him a most exhaustive account of the special fixtures and methods of lighting employed. In this case 5 foot-candles had been regarded as the correct amount of light for the reading tables. General illumination and also local lamps were provided. On the tables Holophane shades, on which green shades were superimposed, so as to screen the eyes completely, had been employed.

Another feature of some libraries was the erection of chandeliers over the gangways. If this was necessary from the architectural standpoint, it might be very injudicious from the lighting point of view, as not infrequently most of the light was thrown downwards on the gangways, and very little on the tables. However, the conditions might be considerably improved by the use of suitable shades designed to throw the majority of light in the desired direction. The "gangway-system" was originally the method of lighting employed in the Patent Office Library. Recently, however, local table lamps had been added, and this enabled half the chandeliers to be extinguished. By the kindness of the librarian some tests had been made, and he was informed that, as a result of the change, the illumination of the reading tables had been increased ten times (from about 1·6 to 16 foot-candles); at the same time the total current consumption in this portion of the library would now be reduced by one-fifth of a unit per hour, even supposing that all the table lamps were in use simultaneously. He might add that in this case even more satisfactory results would probably have been obtained had it not been that the standards on the tables were prematurely purchased and fixed, irrespective of the kind of shades to be employed.

Chandeliers over the gangways were also employed in the library of the Institution of Electrical Engineers. He was told that the resulting illumination on some of the reading tables was at present only about 1 foot-candle, but he understood that the lighting arrangements were not yet complete.

In conclusion, Mr. Gaster mentioned that during the last fortnight the Hon. Assistant-Secretary, Mr. Dow, had visited many of the libraries in London and studied the actual conditions of illumination. The figures he was about to give should at least serve to show that serviceable measurements of illumination could be made, and that useful lessons could be drawn from them as to possibilities of improvements and economies in existing schemes of lighting.*

Mr. J. S. Dow said he ought first to

* The complete data relating to these libraries were found to occupy too much space to be conveniently included in this discussion: they are now embodied, with additional information since received, in a special article on p. 97 (Ed.).

express his great appreciation of the kindness of the librarians at the different institutions visited, who had invariably granted the necessary facilities, and had often taken a considerable amount of trouble on his behalf.

Mr. Dow then proceeded to explain how measurements were taken with the "Holophane Lumeter." One of the chief points to be noted was the fundamental distinction between different types of libraries. For example, some libraries, such as the British Museum, catered exclusively for the student, and one should therefore intentionally select conditions which were restful and disposed the mind to study. In such cases anything at all irritating or glaring must at all costs be avoided.

Even in a public library one had to distinguish between the reading-room, the reference library, and the lending library, each of which fulfilled distinct purposes, and required distinct styles of lighting. It was interesting to observe that, in the various public libraries visited, a distinction was almost always (though perhaps involuntarily) made between the reading and the reference library. In the former case the usual practice to render it attractive and cheerful, was to give the walls a light tint, and general illumination was relied upon. In the reference room, on the other hand, which was intended for people engaged in serious reading and using the room for longer periods, local lighting by well-shaded lights, coupled with more or less subdued surroundings, seemed to be preferred. The question had been raised, What should the desirable relation between the brightness of the illuminated book and the surroundings be? The contrast ought not to be excessive—according to Prof. L. Weber of Kiel not more than 100:1, so as not to fatigue the eye. On the other hand, the book should, presumably, be brighter than the background, so that there was nothing to distract the eye, and the attention was riveted on the work. Probably in no case investigated, however, was this limiting ratio, 100:1, exceeded; in most cases it was more like 10:1.

As regards the illumination on the reading tables in the different libraries, the values, while not always as high as might be desired, was seldom really poor. In the British Museum the reading tables receive about 4 foot-candles, in the Patent Office the value immediately below the table-lamps is as high as 15 or even 20, in the alcoves in the same library it was more like 2. The general trend was between 2 and 5 foot-candles. There were, however, certain cases in which the illumination falls below 2 foot-candles, and this is distinctly insufficient.

The chief objection to be raised against the general nature of the lighting was usually the presence of unshaded naked lamps which were often visible out of the tail of the eye, and somewhat distracting to the reader. In many libraries visited the use of frosted lamps of the same candle-power, in connexion with appropriate concentrating shades, would have vastly improved the conditions in this respect, and at the same time considerably increased the downward illumination on the tables.

One of the chief difficulties was the efficient lighting of shelves. Here again the system of lighting and the amount of light necessary were different in a lending room from what they would be in a reference library where the books are selected in a more or less leisurely manner. But in almost all cases the prevalent system of putting an imperfectly shaded lamp near the top of the shelf gave unsatisfactory results. The distribution of light over the shelf was most uneven, the top shelf often receiving as much as 5–10 foot-candles and the lowest one only about 0·5. Were a uniform brightness of, say, 1–2 foot-candles secured, the results from the reader's standpoint would be much improved and the consumption possibly less. Again, the shades often only partially covered the filaments of the glow-lamps, so that an impression of glare interfered with the comfort of any one searching the titles. One of the few libraries where the shelf-lights are adequately screened from the eyes is the British Museum.

A scientifically designed shade, giv-

ing the correct polar curve of light-distribution for the local conditions, and also screening the eyes, was needed. He added that he understood that Mr. Mackinney had for some time been engaged on the design of a reflector having these qualities.

In conclusion, Mr. Dow threw on the screen a table summarizing the chief data collected, including the watts per square foot, pointing out that in some of the libraries in which this item was highest the illumination on the reading tables was, nevertheless, far from satisfactory. In many of these cases he thought that a few simple alterations might considerably improve the lighting, although it was naturally not so easy to secure perfect conditions as when the installation was designed on the most scientific lines from the start.

Mr. L. C. Wharton (British Museum) said that in the place where he generally had to work he had to contend with his own shadow,* but this was not a feature of the lighting of the British Museum, because in the Reading Room it was possible to read at any one of the tables quite comfortably. It was even possible to read by the aid of the arc-lamps alone in places where there were no standard lamps.

Mr. H. V. Hopwood (Patent Office) wished to make it clear that the lighting of the Patent Office Library was in a transition stage, and that experiments were still going on. In his opinion such a matter was not a problem of lighting libraries in general, but of giving the reader in any particular library exactly what he wants, under varying circumstances, which latter might be due to differences in the reader, in the architect, or in the building. With existing buildings they had to deal with what they had, and the lighting must be suited to existing circumstances. He did not wish the Patent Office Library to be compared with any ordinary library. There was, perhaps, a different type of reader there; not the man who came to read the book from cover to cover, but the man who was searching and comparing, and they had to give him plenty of room, not necessarily for the book he was reading, but for other books which he wished to consult, and this explained to a large extent the wide space between the standards on the tables. He thought the varying amount of light on the Patent Office tables was advantageous, for a man studying engineering drawings for instance, had the advantage of bringing a fine line drawing right under the lamp, and of having a less illumination when he wished to read ordinary matter. An adjustment of about from 17 to 4 ft.-candles on the centre tables he thought was a very useful condition of affairs.

Mr. A. E. Twentyman (Board of Education) said that if the lighting of the library at the Board of Education was unsatisfactory, it was due in great measure to the uncertainty as to which rooms would be used for the purpose. Three separate locations had been selected and rejected because the rooms were required for other official purposes. As a matter of fact, the architect had designed a chandelier which was to be placed in all rooms used for public purposes, and the library being one of these, these chandeliers were placed down the centre of the room. The reading tables—all on one side of the room—are lighted by adjustable lamps suspended from the ceiling. The whole matter, however, rested not with those responsible for the Library, but in the hands of the Office of Works.

Mr. W. R. B. Prideaux (Reform Club Library) said the main library at the Reform Club was one long room, for the general lighting of which there were three clusters, one in the centre of the room, and one towards the two ends. This served for the general lighting and also for the lighting of those who sit around the fire places which are near the clusters. In addition there were tables all down the room, and on these there are the usual standard lamps. All of these are fitted with green shades, so that they do not interfere with the readers' eyes. He was not quite satisfied with the lighting of his own desk and thought the height

* Because the lights were arranged to light the shelves and not the desks.

of the standard was not quite correct, or perhaps the shape of the shade was not accurate. The book shelves were lighted from the clusters in the ceiling.

Mr. R. W. Chambers (University College Library) said that the lighting in the central library at University College was by means of standard lamps on the tables, together with clusters of lamps running down either side of the room for general lighting. He raised the question of whether it would not be better to carry out general lighting by concealed lamps running round the cornice of the room. The central library in University College had a white barrel roof, and with reflected light from concealed lamps running along the cornice he thought the general illumination would be much more satisfactory. The table lamps were satisfactory and would, of course, be retained with the system of reflected lighting which he had suggested.

Mr. C. T. Davis (Wandsworth Public Libraries) said he had been disappointed as he had hoped to hear some details of the cost of illumination in libraries. At West Hill Library, after careful consideration of tenders, it had been decided to use gas (he would add that over nearly all the burners were ventilating shafts). The Librarian's task was to adapt the buildings that were given him to the best advantage and Committees often listened to the architect and engineer rather than to the librarian. In one case a certain system of lighting which had been recommended by an expert electrician was a failure as far as concerned the reading-room. In another place the lending library had been lighted with all the lights on one switch, with the result that when the librarian wished to have light at his desk he had to light up the whole of the room.

Mr. W. Whitaker (Croydon Libraries Committee) said it used not to be the custom for the librarian to be consulted in the building of a library, but now he seemed to be getting more aggressive, and quite rightly insisted on being heard. The librarian, the architect, and the illuminating engineer, looked at the matter from different points of view, with the result that there was controversy. But he ventured to say that never in this world would the librarian or the architect or the illuminating engineer, or all three fused into one, succeed in satisfying every reader and every kind of person. Comparatively little had been said about reflected lighting. This form of lighting was very effective in illuminating the specimens at the lower part of the Museum in Jermyn Street. It might be expensive, but that was a secondary matter. All lighting systems might be cheaper in the future. At the same time, reflected lighting would not do in all rooms, but only where there was a white or pale ceiling. For instance, the room of the Society of Arts with its decorated ceiling and walls, could not be so treated. Similarly at Croydon, where there was a very fine reference-library, originally built as a hall, but which had been gradually appropriated by the Libraries Committee. In such cases they must take the rooms as they exist and light them in an appropriate way. This showed how different various places were, and he was pleased that no universal dogmatic statements had been made in the discussion. It was necessary that they should proceed in the true scientific method, by experiment, as only in that way would they get near perfection.

Mr. L. Inkster (Battersea Public Libraries), in answer to Mr. Davies on the question of gas *versus* electricity, said that ten years ago he gave up gas, and never regretted doing so. At the same time, they were still experimenting with electricity and did not think they had got things perfect yet, but they were trying to adapt the light to the varying conditions of their rooms, and believed they would succeed in the course of time.

Mr. F. Pacy (Westminster Public Libraries) said that the question seemed to resolve itself into one of expert advice. It was very difficult for the librarian to come to any conclusion, and he would suggest that he ought not to rely solely on the architect nor yet upon the Library Committee. He would suggest that the illuminating engineer should be consulted and should have a free hand. He might add that

even if a corporation possessed an electrical engineer he was not necessarily the best person to advise as to the lighting of buildings, because his function was to sell current. One other point he might mention was that in order to get efficient results it was necessary for librarians to have the money to keep their walls and ceilings as bright as possible.

THE PRESIDENT, after announcing that the discussion would be adjourned for a fortnight, referred to the suggestion of Mr. Davies that comparisons between gas and electricity should be instituted. Any such comparisons he would most certainly object to, as the function of the Society was to consider the scientific application of illumination quite apart from the source of the light. Mr. Whittaker had suggested that they should go back to experiment, but the fact was they had experimented and did not need to be doing it over again. From past experience, certain generalizations could be drawn, and the information applied in a practical way. For instance, from the discussion that evening it had come out that for table illumination they must have a minimum of 4 to 5 foot-candles, and for shelf-lighting, in order to read the titles of books, there must be a minimum of 1½ foot-candles. If they could specify such things, then they had gone a long way, because the contractor could be compelled to carry out the terms of the specification in the same way that the terms of an ordinary engineering specification were enforced. They had been told of differences in illumination on different parts of a newspaper. Would they think of accepting a boiler, for instance, guaranteed to stand 100 lbs. pressure per square inch if the contractor supplied one which would stand 500 lbs. per square inch at one part and only 80 lbs. at another ?

The discussion was then adjourned until Tuesday, January 31st.

MR. P. J. WALDRAM (communicated.) —The daylight illumination of libraries and reading-rooms is almost as important as their artificial lighting. The use of public reading rooms and reference libraries is by no means confined to the evening hours, and whilst artificial illumination can be varied, adjusted, and improved at small cost, the proportion of outside daylight admitted by the windows is in nearly all cases incapable of alteration.

The value of high angle light is gradually becoming recognized by architects, but not by any means to the extent it deserves. Not only is the light from high angles far more powerful, especially in towns—not only does it illuminate rooms better, but it is the light we read by. Practically every reader unconsciously adjusts his reading matter and the position of his head so that his eyes receive the light which is reflected from the paper at an angle of from 70° to 85° above the horizon.

The superiority of top light over vertical windows, and of high window heads over low, will be apparent to any one who studies the subject—whether perfunctorily or with the assistance of actual photometric measurements and records. It is possible to see to read comfortably under the top lights of the Patent Office Library, the British Museum Reading Room, the St. George's Library, Buckingham Palace Road, long after the daylight has failed absolutely in adjoining rooms lit with vertical windows with clear uninterrupted horizons.

The proportion of outside daylight which would be obtained from window heads 10 ft. high under normal town conditions would be about 1/1,000 in the centre of the room, whereas the proportion enjoyed by means of window heads 14 ft. high flush with the ceiling might be four or five times as much. Under the glazed dome of the British Museum Reading Room a proportion of at least 7/1,000 is enjoyed, and the Patent Office Library receives 5/1,000 from its top light. Smaller top-lit libraries have given higher results. As an example of the value of top light, I have seen an old compositor setting up nonpareil type under a small dirty skylight long after the street lamps were lit on a wet day in November and found it possible to read the type myself with ease.

I would therefore venture to urge most strongly that every reading-room and library should, wherever possible, be lit from the ceiling instead of the walls. Whatever may be the disadvantages in heating, ventilation, down-draughts, chance of leakage, &c., the primary object in a reading-room is reading.

Where top lights are impossible, then the window heads must be high, at least 13 ft. above the floor, and as much more as possible. It is also important that they should extend flush with the ceiling, and it is most essential that the latter and as much as possible of the upper walls and general decorative scheme should be light in colour.

It will be found that light floor coverings and light-coloured fittings can distinctly improve an otherwise unsatisfactory room.

[It is proposed to deal with some other contributions since received on this subject, and the adjourned discussion on Jan. 31st, in our next number.—ED.]

Some London Libraries and the Methods of Illumination Employed.

PREVIOUS to the recent discussion on library lighting at the meeting of the Illuminating Engineering Society on January 16th a visit was paid, by the courtesy of the librarians in charge, to the following libraries :—

The British Museum, Guildhall, Royal Colonial Institute, Patent Office, Surveyors' Institution, Fulham, Islington (Central), and Islington (North) public libraries.

The visits were necessarily made somewhat hastily, and time did not permit of the list being extended, although it is hoped shortly to add to these data by visits to other libraries. The above list was therefore specially selected with a view to variety.

The writer was struck in the course of these visits by the radical distinction to be drawn between the functions of different classes of libraries. For example, the libraries at the British Museum, Surveyors' Institution, and Patent Office, and the reference libraries at Fulham and Islington are in the nature of libraries for serious reading by students. At the Royal Colonial Institute and the Royal Institution they are more in the nature of club reading and writing rooms ; the reading rooms at the various public libraries, on the other hand, seem to be mainly intended for more or less casual reading of magazines and periodicals for short periods, and the lighting problem is therefore distinct. In the same way the shelves in an institution or club library are used in a different way from those in a public lending library, and quite probably demand distinct conditions of illumination.

There are, of course, other distinctions. In a public library, the writer was informed, the expense of lighting is usually deducted from the sum available for books, and economy is therefore very desirable ; under the circumstances the prevalent generosity in expenditure on illumination in many such libraries is distinctly creditable. On the other hand, old-established institutions can afford to spend what is necessary upon the lighting to make things really satisfactory, and expense is not regarded as the first consideration.

Again, the way in which the floor-area is used in the different cases naturally makes a considerable difference in the apparent economy of energy consumption in watts per square foot. In rooms in which every available foot of space is used the figure naturally tends to appear high. In others in which a relatively large area is devoted to gangways and unoccupied space—as, for example, in the Patent Office, and in the reading room of the Royal Colonial Institute—the figure comes out distinctly low ; owing to these and other factors it is not always easy to

draw definite conclusions regarding the relative economy in the different libraries except in conjunction with a full knowledge of the arrangement of the lights and the local conditions.

Nature of Tests and Data.

It was not considered necessary to aim at a high standard of exactitude in collecting these data. A rough calculation of the consumption per square foot of floor-area was made in each case, and the illumination on the reading tables, the shelves, and, in some instances, the attendant's desk, was observed. The measurements of the illumination were carried out with the Holophane Lumeter instrument, which has been previously described in this journal* and permits measurements to be readily ascertained in any plane; the illumination on the shelves was measured vertically, by placing the test-plate exactly over the titles of the books at the part of the shelf studied. In all such measurements it was clearly no use to aim at extreme exactitude, since a very accurate reading has no real meaning unless the conditions under which it was obtained are described with great precision. For example, the values given for the shelves were obtained immediately under the lamps, and at intervals from the bottom to the top shelf; naturally different results would in many cases be obtained *between* the shelf-lamps, but these could not readily be tabulated within a reasonable compass. Again, the illumination on the tables varied considerably in cases in which local lamps were used. The usual practice was therefore to select an average table and record the illumination immediately below the lamp, to get a value, in short, which approximated to that enjoyed by the average reader. Some diagrams are, however, given showing roughly how the illumination on the tables varied in certain cases. As a rule, of course, local shaded table lamps do not give the same uniformity as is secured from good general lighting, but such uniformity is perhaps not always desirable in a student's library.

* *Illum. Eng.*, Nov., 1910.

After these preliminary remarks, let us take the libraries visited in turn and consider the conditions of illumination; at the end will be found a table summarizing the data.

The British Museum Reading Room.

The reputation of the British Museum Library, of course, demands a very high standard in lighting, and it may be said with justice that the conditions appear to be excellent in many respects.

The dimensions of the room are immense. The dome is 140 feet in diameter, larger than that of St. Peter's at Rome. The lighting, as now provided, consists of three sections. Five 300 candle-power arc-lamps, placed high up in the dome, provide the general illumination; they are equipped with specially obscured globes, and at the great height are exceptionally favourably placed to provide general illumination without glare. The circular floor is completely filled by the tables, which are provided with 300 well shaded reading-lamps shaded with opaque screens, and carrying 16 candle-power carbon filament lamps. About 40 carbon filament lamps are also spaced at intervals round the shelves to light the books, and are reproduced in the galleries above.

The illumination on the reading tables was in the neighbourhood of 4 foot-candles; several tables were examined and similar results obtained. It will be seen that the illumination in this case is of the variety of local shaded lamps *plus* subdued general illumination. The freedom from glare is certainly a good feature. The filaments of neither table lamps nor shelf-lamps are visible to the eye. The complete screening from the eyes of the shelf lamps is, indeed, a feature which other libraries might well adopt. The extra illumination provided is, however, very unevenly distributed, the illumination on the lowest shelf being only 0·5 foot-candles, while that on the shelf immediately opposite the lamp is as much as 10. The distance of the lamp from the shelf was about 18 inches. It is interesting to observe that the local shelf-lighting is a comparatively recent addi-

tion, and the general illumination from the arc-lamps originally considered adequate eventually came to be recognized as insufficient.

A large area of the surrounding wall is taken up by shelves; the ceiling, however, is light in tint and had a surface-brightness of about 0·3 foot-candles (apparently a very usual figure for subdued illumination; the ratio of brightness of book to brightness of walls in the libraries visited was usually of the order of 10, well within Weber's limiting value of 100 designed to avoid excessive contrast).

As regards results, therefore, the conditions of illumination seem excellent, but possibly the shelf-lighting could be improved still further by the use of a special reflector designed to spread the light uniformly. The consumption per square foot of floor-area (about 1·5) is unusually high. This is largely due to the fact that exclusively carbon filament lamps, consuming approximately 60 watts each, are employed. Were 20 watt tungsten lamps substituted the consumption might presumably be vastly reduced without materially affecting the light. The writer was informed by the electrician in charge (of whose courtesy in furnishing these details he makes grateful acknowledgment) that the Museum generates its own power, and does so at a low cost, and that it has therefore hitherto been considered cheaper to employ carbon filament lamps; however, the recent extensions of the Museum premises have begun to tax the capacity of the present plant somewhat, and it seems possible that from this standpoint the adoption of metallic filament lamps might be beneficial. The voltage employed is 115, this being specially selected with a view to running the arc-lamps in series.

Some particulars, taken from the official guide, regarding the date at which artificial lighting was introduced are interesting. It is stated that considerations of fire risk prevented any attempt to light the room artificially until 1879, and the first attempts were not very successful; previously, however, it had been necessary to close the rooms at 6 P.M. in summer and 4 P.M. in winter, while occasionally fogs still further curtailed the time during which the library could be used. The original installation consisted in four arc-lamps credited with 5,000 candle-power each; in 1893 the arc-lamps were reduced to 300 candle-power each, and the local incandescent table lamps were introduced. The special shelf-lamps were introduced two years later.

The Reading Room contains ample accommodation for 458 readers.

The Guildhall Library.

The interior of this library is venerable and interesting. The reference library is lighted by pendants hung down the centre of the room over the reading tables, frosted 110 watt metallic filament lamps, in conjunction with opal shades, being employed. The alcoves are lighted by single 32 candle-power metallic filament lamps with the usual opal shade. The illumination on the reading tables in the centre of the room was about 2 foot-candles, occasionally somewhat more. The illumination in the alcoves was low, 1·7 immediately under the lamps, but only 0·7 at the far corners. This must be considered insufficient for reading purposes, but it is said to be a practice in some libraries to make the illumination weaker in the alcoves than in the centre of the room, so as to attract readers to the centre tables, where they are within view of the attendants. The illustration shows the nature of the interior, but the system of lighting shown has been superseded and the distribution of the tables altered since the photograph was taken.

Special lighting by a series of naked metallic filament lamps is used in the alcoves where the catalogues are situated. The use of half-frosted lamps in the centre is a good feature as regards avoidance of glare (curiously enough, in very few libraries were frosted lamps used). The chief suggestion that might be made as regards the lighting of this library is that its historic interest and the nature of the interior would justify greater generosity in the choice of harmonious fittings; the present simple pendants, even if considered adequate from the

utilitarian standpoint, appear crude and lacking in dignity.

In the reading-room general lighting by simple pendants with metallic filament lamps (with clear bulbs) and ordinary opal shades is provided. In one half of the room the lamps are arranged in two parallel straight lines over the tables; in the other they are spaced irregularly, apparently with the object of lighting the newspaper rack. The illumination on the tables was relatively good, about 3½ foot-candles.

FIG. 1.—The Guildhall Library.

The news-racks received about the same value. It may be noted that the plan followed in this case of having light walls and strong general lighting yields a much more uniform illumina-

tion on inclined newspaper-racks than is secured by local lamps placed close to them; the clear bulb lamps have a somewhat glaring effect. At the Guildhall, as in most cases, the conditions of illumination in the reference library are the more subdued, those in the reading room the more "cheerful."

Fulham Public Library.

Turning next to public libraries, we may refer to that at Fulham. The fittings and lighting arrangements here are regarded as of a specially elaborate character. In the Reference Library three varieties of lighting are employed. There are a few pendants to provide some general illumination, special table lamps with well-shaded frosted metallic filament lamps, and shelf lamps at intervals. The conditions of illumination are in many respects excellent in this room. As will be shown later, however, the distribution over tables and shelves is not very uniform. The shades on the table-standards are of deep green glass; they completely screen the lamps (which are frosted) from the eyes of readers — a good feature. The shades used on chandeliers and shelves are of frosted glass; they cover the lamps fairly well, but probably absorb a good deal of light, and are presumably not selected with a view to distributing the light in any special direction. The strength of the illumination under the reading lamps (4 foot-candles) is good. (It may be mentioned that the illumination at the attendant's desk in this room, only 0·4 foot-candles, is not as generous as that provided for visitors.) In this room we find the subdued illumination characteristic of rooms intended for study.

In the Reading Room we find brighter surroundings. The surface-brightness of the ceiling is here 0·5 foot-candles as compared with 0·2 in the Reference Library, and the cream-coloured walls have a surface-brightness of 0·4. The illumination on the reading tables is about 3 to 4 foot-candles, and it is to be noted that more uniform results are obtained owing to the greater number of lamps per table. It is rather curious to note, however, that only alternate table lamps are in use.

The system of lighting the newspaper racks might be improved upon from the illuminating engineering standpoint. The lamps have the usual frosted shade and are so placed that the illumination on the papers is badly distributed, varying from 0·4 to nearly 3 foot-candles near the lamp. As Mr. Darch has pointed out, it is not easy, even with a specially-designed reflector, to get uniform illumination on inclined newspaper racks by local lamps; in addition the rays are apt to be directly reflected from the glaze of paper and any inequalities in the paper (if it is slightly crumpled, for example), become evident when the rays strike it so obliquely. In this case it may be noted that the illumination *on the ceiling* is actually higher than that on some parts of the racks. The illumination of the inclined shelves on which some of the magazines are kept when not in use is open to similar criticism.

It is interesting to observe that in this library the benefit of a low voltage supply for metallic filament lamps is recognized: the pressure was recently transformed down from 200 to 25 volts, and 25-volt 16 c.-p. lamps are used throughout.

Views of the respective libraries' rooms described are shown in Figs. 2 and 3.

Islington Central Library.

The central Islington Library is also a well-equipped one.

In the Reference Library the scheme of decoration is subdued, but owing to the variegated nature of the surroundings, walls and shelves, it was considered hardly worth while to record the surface-brightness. The illumination here is provided by suspended strings of lamps and brackets. No photograph being available, the conditions of lighting are shown roughly in the adjacent plan. General lighting here takes the place of table-lamps. The arrangement of the lamps in strings is certainly peculiar; the chief objection from the illuminating engineering standpoint is again the use of clear bulb lamps, unprovided with any scientifically designed shade. As a consequence a great deal of light is thrown upwards

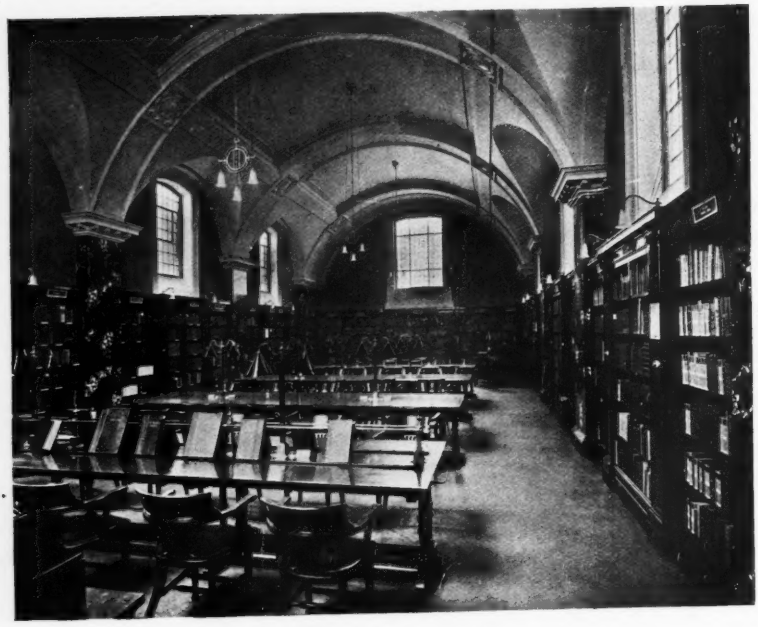


FIG. 2.—Fulham (Reference Library .

FIG. 3.—Fulham Reading Room).

and absorbed by the dark surfaces above, which might profitably be directed on the tables: it is admitted that some light should be allowed for this purpose, but the quantity which escapes upwards seems here excessive. The illumination on the tables, slightly under 2 foot-candles, would doubtless suffice for many people, but is on the low side, and might possibly be increased by the method suggested. In addition, on principle one would prefer that no naked lamps furnishing bright spots of light which are apt to annoy a roving eye should be used.

As regards the shelf-lights, the same remarks as those made on other similar

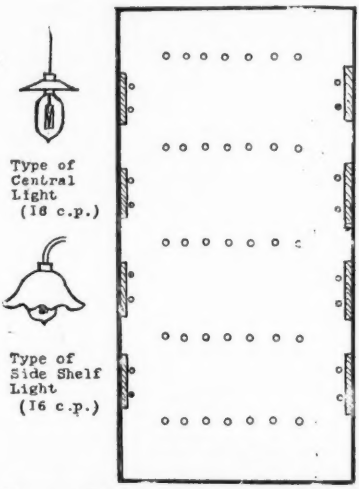


FIG. 4.—Sketch Plan of positions of Lights in Islington Reference Library.

systems may be repeated, the lamp-filament being only partially covered, and thus producing a glaring impression on the eye. This feature calls for improvement, and if the same shades are retained the lamp should preferably be half-frosted.

The illumination of the reading-room is again of a general character—three rows of pendants, each carrying a cluster of three clear bulb metallic filament lamps, with opal shades. The illumination on both sides and central tables is fairly high (3 to 3·5 foot-candles) and very uniform, similar results being obtained on a number of tables tested. The surroundings are, as is usual in reading-rooms, light in character, the surface-brightness of wall and ceiling varying from 0·7 to 1 foot-candles; this is exceptionally high. It means that the brightness of the surroundings is only about one-quarter or one-third of the brightness of the printed page. On the other hand it helps to make the illumination on the tables uniform, and incidentally probably renders the use of naked lamps less glaring than it would otherwise be. There are also brackets down the sides of the room to light the side-tables.

The lending library is illuminated by clusters of lamps at intervals. The nature of the illumination is somewhat similar to that described in the Fulham Library. But the greater distance of the lamps from the shelves makes the illumination from top to bottom more uniform. The use of naked lamps is again to be noted, and the consumption per square foot is on the high side. The energy consumed could probably be considerably reduced by a better distribution of the light.

In this library 100-volt 16-candle-power metallic filament lamps are employed throughout.

GENERAL NOTES ON SHELF-LIGHTING.

It occurred to the writer that a general comparison of some of the methods of shelf-lighting would be of interest, and a rough sketch of these to scale is shown in the accompanying figure. The figures represent vertical illumination in foot-candles.

Without exception the conditions show the same general defect, namely, gradual dwindling of brightness towards the bottom shelf. One would naturally assume that it is equally important to read the titles of books on all shelves, and that uniform illumination is, therefore, to be desired. There is evidently no commonly accepted standard of the intensity needed. One might suggest that a uniform illumination of one candle-foot would be enough in most cases. The double system suggested by Mr. Jast, lamps

being used at top and bottom, would mitigate the defect.

Many of the trough-shaped metallic reflectors, equipped with tubular lamps, now in the market, could doubtless be applied with advantage to shelf-lighting.

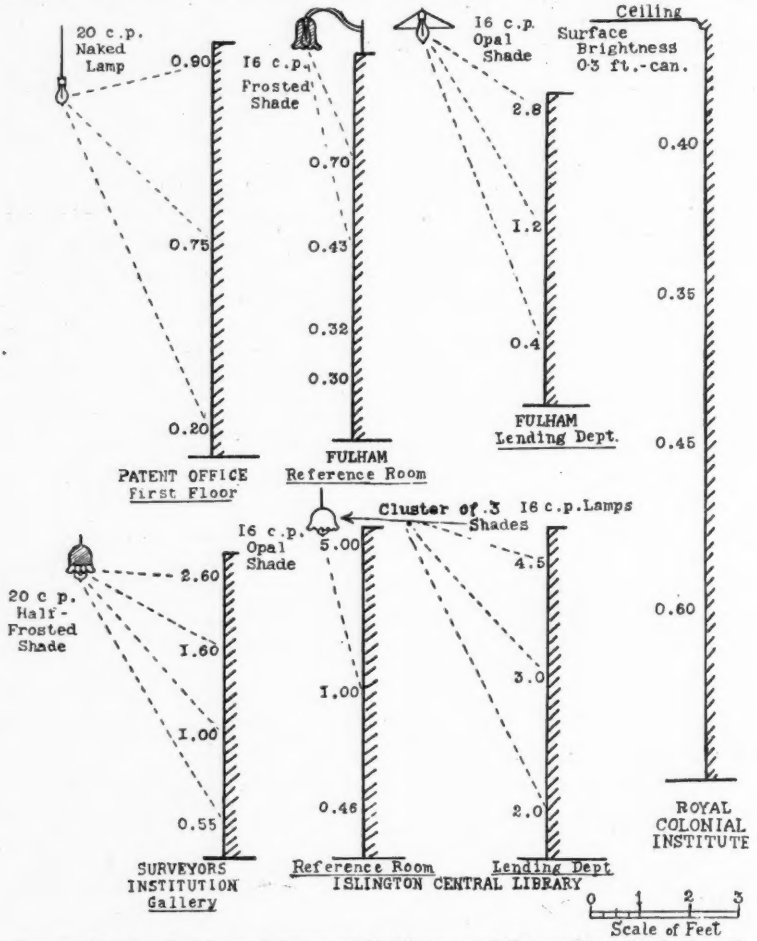


FIG. 5.—Showing Position and Nature of Shelf-lamps, and the resulting distribution of illumination (indicated by figures) in foot-candles.

They at least protect the eye and tend to throw the light where it is wanted.

There is, however, no theoretical obstacle to the design of a form of reflector which would not only screen the eyes, but produce absolutely uniform illumination under specified conditions, and it appears that a shade of this kind has been actually devised by Mr. V. H. Mackinney.

An easily avoided additional weakness in many of these systems is that the unscreened filament of the lamp is visible at close quarters and dazzles the eye; possibly this defect alone counteracts any advantage secured by the extra illumination.

Good general illumination, such as is secured in light-tinted rooms, is conducive to uniformity. If there is a

moderate absence of glare, even weak general illumination may answer (see, for example, the uniform, if low, illumination attained in the Royal Colonial Institute). The method employed in the British Museum was studied too late for inclusion in this diagram; the illumination secured is far from uniform, but it has this advantage that the shelf-lights are concealed from the eye by trough reflectors.

LOCAL TABLE LAMPS.

In a similar manner some of the systems of table-lamps are collected in Fig. 6, the nature of the shades being shown beside the diagram. The figures again represent illumination in foot-candles. Going downwards in the

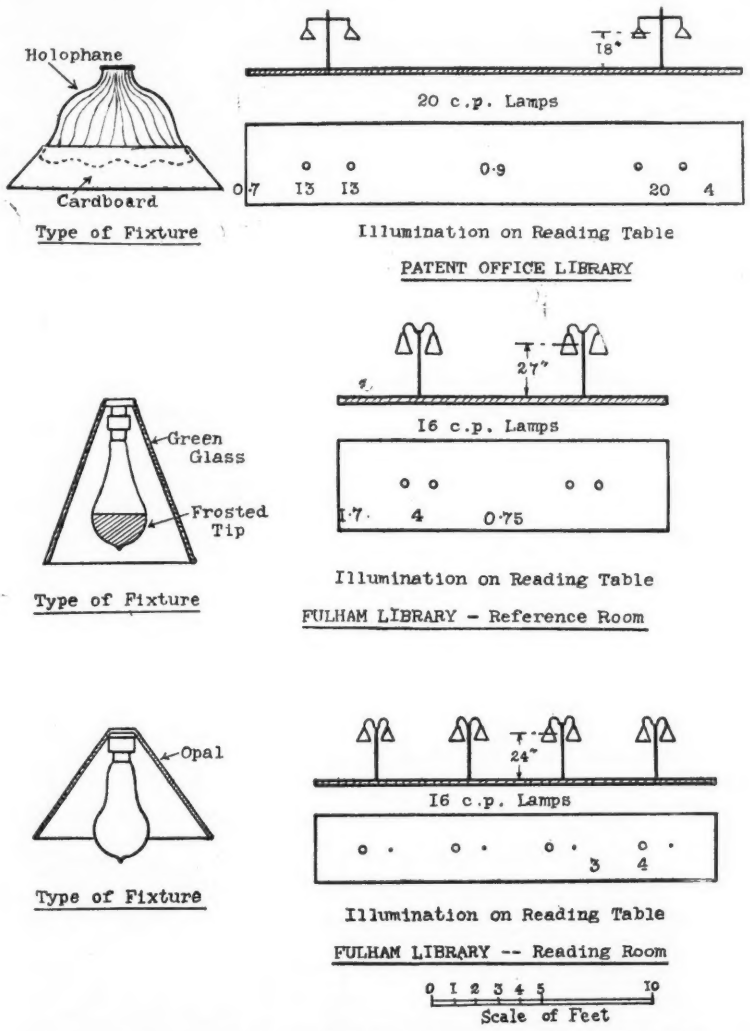


FIG. 6.—Showing nature of local table-lighting and distribution of illumination.

ILLUMINATION—DATA OF VARIOUS LONDON LIBRARIES.

Library.	Nature of Lighting.	Consumption Watts (very approx.)	Watts per square foot floor area.	Illumination in Foot-Candles.			Surface-Brightness of Surroundings (Foot-Candles).
				Reading Tables.	Shelves (bottom to top).	Attendant's Desk Counters, &c.	
British Museum							
Reading Room ...	Suspended Arc Lamps Table Lamps Local Shelf Lights (Galleries)	2500 18·0 2400 4800	1·5	4–5	0·5 – 10	—	Ceiling 0·3
Guildhall							
Reference ...	Pendants	2000	0·25	Centre 2 – 2·5 Bays 0·7–1·7	1 – 1·8	—	Subdued
Reading	Pendants	1200	0·45	3 – 4	(News Rack) 3 – 4		Bright
Royal Col. Institute	Chandeliers over Tables & Brackets, &c.	650	0·35	5 – 8	0·3 – 0·6	0·8, 2	Ceiling 0·3 (Shelves fill walls)
Patent Office	Chandeliers over gangway* 800 Table Lamps ... 700 Alcoves ... ... 2000 Galleries (2) ... 4000		0·25	Centre 10 – 15 (under lamp) Bays 2 – 2·5 Gallery 0·6	Periodicals 0·25 Bays 0·9 Gallery 0·2 – 0·9	Floor, 2, 2·5, 4 Gallery 8	Subdued
Surveyors' Institution	Chandeliers over gangway... 450 Gallery Lamps... 170		0·55	0·4, 0·6, 1·6	Floor 0·16 – 0·8 Gallery 0·5 – 2·6	—	Subdued (Shelves)
Fulham (Public)							
Reference ...	Pendants ... 180 Table Lamps 560 Shelf Lamps 280	920	0·6	4 (under lamp)	0·3 – 1·5	0·4	Ceiling 0·2 Grey Wall 0·09
Reading	Pendants ... 240 Table Lamps* 580 News Racks 320	1140	0·45	3 – 4	(News Racks) 0·4 – 2	—	Ceiling, 0·5 Cream Walls, 0·4
Lending	Shelf Lamps 640		0.5	—	0·4 – 2·8	0·9, 2·0	—
Juvenile	Pendants ... 480		0·55	1·6 – 2	0·6	0·9	—
Islington (Central) (Public)							
Reference ...	Suspended Lines of Lamps, Brackets	1000	0·45	1·8 – 2	0·4 – 5	—	Subdued
Reading	Pendant Clusters Brackets	1000 500	0·5	3 – 3·5	—		Walls and Ceiling 0·7 – 1·0
Lending	Shelf Lamps	1500	0·7	—	1 – 4·5	2 – 3	—
Islington (North) (Public)							
Reading	General Pendants	700	0·4	2 – 2·5	—	—	Bright.

* Half not in use and therefore not here included.
† Assuming all lights turned on.
N.B.—It is throughout assumed that all table lamps provided are turned on simultaneously unless otherwise stated.

diagram we see a progressive tendency in uniformity in illumination. In the Patent Office it is presumably out of the question to use the centre of the table for reading purposes; it serves as a resting-place for volumes collected. The very high illumination, as will be seen, has some special justification.

In the Fulham Reading Room much better uniformity is attained; possibly this is regarded as desirable in a reading-room and less so in reference libraries. The uniformity is attained by placing the lamps at more frequent intervals. At present the standards would appear to be used rather uneconomically, as only one lamp in each is lighted. Even so, the illumination varies from 3 to 4 foot-candles. An important point from the reader's standpoint is that the tips of the lamps should not project beneath the shades. They should be completely screened.

Further details as to how far uniformity is really desirable would probably be of service to lighting engineers. If, however, uniform and sufficiently high illumination on the table at a minimum cost is what is wanted, it seems quite possible that a scientific and standardized design of standard and shade and fitting would give more efficient results than those attained here. The important point is to determine, before the tables are equipped, exactly what is wanted, and scheme out the best conditions. At present there seems no standard practice. The strength and permissible variation in illumination, the distance apart of the lamps and their height above the table, vary in different libraries. There seems no reason why such conditions should not be decided once and for all.

General Summary.

The final table contains a brief summary of the chief data regarding the different libraries visited. It should be studied in conjunction with the account of the conditions in each case. If it serves no other purpose, it at least shows the variation in existing practice and the lack of any coherent scheme bearing on the amount of light desired and the most economical method of getting it.

[Discussion of the lighting of some of the libraries in this list is postponed, owing to pressure of space, till our next number, when, it is hoped, fresh data will also be forthcoming; meantime grateful acknowledgment should be made of the courtesy of the librarians in granting facilities for these tests to be carried out.—Ed.]

(To be continued.)

The London Ophthalmological Exhibition.

(To be held at the rooms of the Medical Society, 11, Chandos Street, Cavendish Square, London, W., on March 10th and 11th, 1911).

An interesting exhibition, is to take place in March this year, at the rooms of the Medical Society of London. The exhibition will comprise displays of optical and physical instruments, apparatus for measuring light and illumination, &c., demonstrations of colour-perception, ophthalmological apparatus, &c.; it will, in short, cover much of the ground of common interest to the medical profession and the illuminating engineer.

Besides the exhibition of apparatus it is proposed that a series of short papers and demonstrations in connexion with various subjects of interest will be arranged, and particulars of the programme will be available shortly.

Invitation cards, catalogues, programmes, and further particulars can be obtained from the Secretary, 11, Chandos Street, Cavendish Square, London, W.

A Few Queries in Connexion with Electric Lighting.

(To which replies are invited from readers of this journal, members of the Illuminating Engineering Society, and others interested in matters connected with illumination.)

In December, 1910 (page 739), we published the following series of queries dealing with electric lighting, in reply to which interesting contributions have since been received from Prof. Elihu Thomson and Mr. J. S. Codman:—

1. What is the maximum efficiency attainable from modern incandescent lamps, arc-lamps, vapour lamps, &c., in practice?

What do you regard as the most accurate and convenient method of expressing "efficiency" (*i.e.*, in terms of mean spherical C.P., mean hemi-spherical C.P., or candle-power in some prescribed direction; watts per C.P., C.P. per watt, or lumens per watt, &c.)?

What useful life may be looked for from modern incandescent lamps and what is the maximum number of burning hours now to be secured for under the most favourable condition from open, enclosed, and flame arc-lamps at the present time?

2. What system of electric lighting yields the closest approximation to the spectrum of daylight, and what special arrangements can be conveniently applied to obtain this result efficiently?

3. What is the best method of testing the steadiness of electric sources of light, and what variation should be regarded as permissible in practice?

4. How far is it possible and desirable for electric supply companies to assist consumers in the location and use of lamps and fixtures with a view to securing the best conditions of illumination? What form of co-operation is to be recommended for future adoption between the lamp-maker and the central station, and what facilities already exist in this direction?

5. To what extent, in your experience, will illuminating engineers be hampered in drawing up lighting specifications, by the absence of precise standardisation of lamps, lampholders, shades, and reflectors such as exists in the United States?

6. In view of the greater brilliancy of modern incandescent and arc-lamps is it desirable that some form of diffusing globe should be employed to screen lamps in the streets and in interiors?

Prof. Elihu Thomson (General Electric Co., West Lynn, Mass., U.S.A.):

1. Naturally the efficiency attainable from modern incandescent lamps depends upon the life which is desirable, and, so far as I know, there is no hard and fast rule to follow. Where energy is cheap low efficiency lamps should naturally be used, and long life attained, but where it is relatively expensive the life of the lamp will naturally be sacrificed to attain higher efficiency. In the United States the conditions vary throughout the country to a considerable degree, and these matters are largely local. Common efficiencies for metallized carbon filament lamps range about 2½ watts per candle and Tungsten lamps from 1 to 1¼ watts per candle. The average life for carbon filament lamps will be about 800 hours. Tungsten lamps should give from 500 to 1,000 hours.

Arc lamps are used with such varying current strengths, and open and enclosed, that even with the carbon arc it is practically impossible to arrive at any standard of efficiency. This is all the more true when we have to deal with the innumerable combinations of luminous flame arcs. If the luminous flame arc and the enclosing globe gives a candle-power at an expense of say from ⅓ to ½ a watt, the result is to be regarded as a good one in practice. It may be said that what is known as

the Standard Edgewise Wound Carbon D.C. Lamp for 110 volts, using 5 amps., ranges to 150 hours of burning for one set of electrodes, while the 4-amp. D.C. Luminous Arc operates under a guarantee of 150 hours life of electrode, but generally gives from 175 to 200. The sections of the electrodes are made very nearly proportional to the current, and with varying size of electrodes it is possible to calculate the life fairly closely, as the consumption varies with the cross-section and is very nearly proportional to the current with any given cross-section.

In regard to the method of expressing efficiency, while usage causes us to speak of watts per candle-power, I think it would be preferable if we used candle-power per watt and the candle-power were taken in each case as "spherical candle-power."

In the absence of any other standard, it is considered that the useful life of incandescent lamps be generally taken as the life up to 80 per cent. of the candle-power. Manifestly, there can be no hard and fast rule, as then the matter is governed—as it should be governed—by the cost of energy in relation to the cost of the lamp.

The time of burning without retrimming of enclosed and open arc lamps is very different for different types, depending upon the size and composition of the electrodes and current strengths, &c. The ordinary duration for one set of electrodes and enclosed carbon arcs is about 125 hours of burning, and with magnetic electrodes and magnetite arcs 175 hours. Of course electrodes made of carbon loaded with substances giving luminous flame vary greatly in life, according to their composition. In some types as much as 18 hours per electrode has been obtained.

2. Undoubtedly the light from the positive crater of the carbon continuous current arc.

3. I do not know of any method of testing the steadiness of electric sources of light which has been adopted in practice, and the amount of variation from absolute steadiness is, of course, a matter which is entirely dependent upon the conditions of service, and somewhat upon the taste and judgment, of the one who is using the light. It is probably unquestionable that a highly economical light for the lighting of large spaces would be adopted, even though it be not so steady as less economical sources.

4. This does not appear to me to admit of any direct answer. There should naturally be a mutual understanding between the supply companies and consumers on the points in question. The consumer, of course, is interested in obtaining the best illumination for the minimum of expenditure, and it is probably to the interest of the supply company to assist as much as possible in reaching this desirable end.

5. I am unable to give any answer which would satisfy me.

6. In regard to inquiry 6, diffusing globes or screens are not so necessary in street lighting unless the lamps are so low down as to be directly in front of the eyes or within the lower range of the vision. In interiors, of course, some diffusing means should be employed which, while costing more for light on account of absorption may, on the whole, produce a far better effect, on account of the absence of glare.

J. S. CODMAN (Boston, U.S.A.) :—

Query No. 1. Second Part.—When it is a question of comparing the illuminating value of two light sources in a general way, without regard to any specific use of them—that is, when we desire to answer the simple question of which gives the most light or has the highest light giving efficiency—it would seem to be beyond question that the only basis for such a comparison is the total light flux of the sources whether expressed in lumens, mean spherical candle-power, or any other flux unit.

To compare light sources by any selected portion of the flux, such, for example, as the portion delivered below the horizontal, is clearly wrong,

unless we are considering a specific problem or class of problem of which the conditions are such that only this portion of the flux is of value.

The use of the mean lower hemispherical flux is very seldom a proper basis of comparison. In the case of street lighting it comes nearer to being a proper basis of comparison than in any other case which is likely to arise; but even in street lighting, Mr. A. J. Sweet and others have shown that it is usually undesirable to have much, if any, light above an angle of 60° with the vertical. If this idea be correct, the proper basis of comparison for street lighting is the flux through the zone between zero and 60° rather than the mean hemispherical flux.

In the case of interior lighting, the mean hemispherical flux is a still more improper basis of comparison, since it ignores the upward flux which, in most cases, is necessary to give proper illumination of walls and ceiling, and much of which besides may be reflected down again. Also in interior lighting, the flux sent out below the horizontal and within 20° of it may very often not be as valuable as the flux thrown directly upward to the ceiling which, after only one reflection, is turned again toward the plane of illumination.

In the general comparison of lamps by the total flux, the lamps should be taken unequipped with any appliances which may absorb flux, except those which are necessary to the operation of the lamp under all circumstances. For example, the incandescent lamp should be taken without globe or reflector and with clear glass bulb, so that the only light from the filament which is lost is that intercepted by the base of the lamp and the glass of the bulb. An enclosed arc lamp should be taken without globe or reflector except the inner globe necessary to its operation, and this should be of clear glass.

When it comes to the comparison of light sources for particular purposes, there is usually no portion of the flux which can be taken as a basis of comparison. Generally speaking, what is desired is a knowledge of the *total* flux and just how that flux is distributed. In other words, the candle-power curve of the light source or something similar to it is needed.

In regard to the question of the best manner of expressing luminous efficiency, this partly depends on the term considered the best for expressing luminous flux. For this the writer greatly prefers the term "lumen" to "mean candle-power." In the first place, the flux through different zones cannot readily be compared by means of mean candle-power, since in doing this we are practically using a different unit of flux for each zone. For instance, the mean spherical candle-power or mean spherical candle is a flux unit of twice the size of the mean hemispherical candle, three times the size of the mean 60° candle, and bears, to other mean zonular candles, a less simple relation. Of course, all zonular flux values could be expressed in spherical candles, but this would unquestionably cause confusion.

Another excellent reason for expressing flux in lumens is because it makes very clear the relation between the generated flux of any lamp and the possibilities of the lamp for illuminating a given area. Dividing the flux of the lamp (or any assumed percentage of it which may be considered as effective in the particular case) by the area, the result is the average illumination in lumens per square foot (foot-candles), lumens per square metre (metre-candles or lux), &c.

Having argued in favour of the lumen as the unit of flux, it naturally follows that the writer prefers to express the relation between flux and energy consumption in terms of lumens and watts; and he would further state, that in his opinion it is, as a rule, preferable to express this relation as the "duty" of the lamp in terms of "lumens per watt" than as the "specific consumption" of the lamp in terms of "watts per lumen."

Lectures on Illumination.

THE special course of six lectures on illumination now being delivered by Mr. J. S. Dow at the Westminster Technical Institute commenced on Friday, January 13th. Previous to the first lecture Mr. L. Gaster said a few words regarding the origin of the course, and congratulated the Westminster Institute and its Principal, Mr. J. Stuart Ker, on the enterprising step it had taken.

The first lecture was devoted mainly to gas lighting. The lecturer, after a brief reference to the historical development of illumination, explained that he could only pass in rapid review the many interesting developments that had taken place in the last century. He gave some account of the early difficulties of pioneers in gas lighting, and traced the development of burners from the early flat flame up to the high-pressure systems of to-day. Special reference was also made to the systems of automatic distance control, and finally some account was given of recent progress in acetylene, petrol-air gas, and incandescent oil lighting.

A feature of the lecture was the representative collection of lamps and appliances exhibited. Tilley's high-pressure gas system was shown in operation, and three burner lamps of Messrs. A. E. Podmore, Messrs. W. Sugg & Co., and New Inverted Gas Light Co., for which 30 c.-p. per cubic foot of gas is claimed, were exhibited, the lecturer alluding to the great progress made in low pressure street lighting by gas. The Degea burner and the Telephos and Pneumatic distance lighting systems were also explained, and the action of the new Broadberry distance-lighter (which is referred to in the Trade Notes section of this number) was demonstrated. The excellence of the display of gas lighting apparatus was in large measure due to the courtesy of the Gas Light and Coke Co., who supervised the fitting up of the exhibits.

Among the other exhibits mention should be made of the 30 light petrol air gas plant of Machine Gas, Ltd., the Blanchard incandescent paraffin portable lamps, incandescent spirit lamps (Messrs. J. Norden), some portable acetylene lights and flare lamps from Imperial Light, Ltd., and the dissolved acetylene outfit for motor-cars shown by the Acetylene Illuminating Co.

In the second lecture progress in electric lighting was dealt with in a similarly comprehensive manner. A special series of Excello and enclosed arc-lamps of the Union Electric Co., Ltd., lighted the hall and the "Economy" system of combining these lamps was shown. Two types of the Jandus Regenerative 5-ampere flame arc-lamp, one for general and one for shop lighting, were shown in operation, and mercury vapour lamps of the Cooper Hewitt and Silica type were shown by the Westinghouse Cooper Hewitt Co. The "Silica" lamp, which has only been recently introduced, and which has recently been described in this journal, attracted much interest. Selections of the latest types of metallic filament lamps were also shown. Siemens tantalum lamps and tungsten lamps of the "Z," Mazda, and other types, were on view. Special mention was made of the recent introduction of drawn tungsten wire filaments as exemplified by the latest type of Mazda lamp of the British Thomson Houston Co., and the "Onewatt" lamps of Messrs. Siemens Bros., Nernst 1 ampere and projector lamps were also shown and described. The lecturer laid stress on the peculiar difficulties that had been overcome in manufacturing metallic filament lamps, and their distinctive properties as compared with carbon ones; the sagging of the filaments with heat, and the manner in which this sag is taken up by the supports, was demonstrated by projecting the filaments on the screen with a lantern, and an experiment was shown illustrating the difference in time taken to light up by carbon and metallic lamps.

In conclusion, it was pointed out how these two lectures had shown the bewildering variety of illuminants now available, and the difficulty in making the best selection for the particular circumstances.

On January 27th the lecturer, having considered illuminants, turned to the other end of the chain connecting the source and the impression received by the eye. He pointed out the importance of considering *the eye*, and traced the growing recognition of the importance of avoiding glare, which had formed a prominent feature of recent discussions of the Illuminating Engineering Society. The distinctions between daylight and artificial illumination were considered, and the value of functions of shades, in moderating glare and directing the light where it is needed, discussed. A shade it was pointed out might serve a variety of purposes: it may screen the eyes and subdue intrinsic brilliancy, may be a decorative object, may serve to soften shadow, and lastly, may be intended not only to diffuse but also *to redistribute* the light. Lantern slides were shown illustrating various polar curves of light distribution and the methods of modifying these by proper shades and reflectors. A feature among the exhibits on this occasion was the display of Holophane glassware and Tantalum lamps; various types of Siemens metallic reflectors for shop lighting were shown, and the "Spookie" and other varieties of shades of the Simplex Conduit Co. An exhibition of various ornamental shades for gas lamps was also arranged by the Gas Light and Coke Co. Special reference was also made to the value of appropriate shades for street lighting units, and the effect of the Excello dioptric globe in modifying the natural curve of light-distribution of the flame arc was exhibited and explained.

In conclusion, the lecturer pointed out the tendency towards recognition of the shade and reflector as an essential part in a light unit and the modern desire to use light in a decorative manner and not "raw"; in the next lecture, he added, it was proposed to deal with the measurement of light and illumination.

CORRESPONDENCE.

Public Street Lighting.

We have received from Mr. J. Eck, manager and chief engineer of the Union Electric Co., Ltd., a letter on this subject, of which the following is a slightly abbreviated version:—

I notice that Herr Göhrum, in an article on the æsthetic aspects of street lighting in the January number of *The Illuminating Engineer*, has been comparing the qualities of electric arc-lamps and incandescent gas lamps as regards uniformity of illumination. In doing so he appears to have taken an antiquated form of arc-lamp, long since discarded for the purpose he is considering; one might as well compare the bat's wing with the latest type of high-pressure gas for efficiency.

I can only suppose that the author is not acquainted with the results attained by using the latest forms of flame arc-lamps. Let him take, say, curve II. on p. 12 of the same journal in which his article appears, which relates to a 12 ampere flame arc-lamp, and re-draw the diagram presented in his article. If he will also state the mean hemispherical candle-power of the incandescent gas lamp, its name, and the source of information on which his curve is based, we shall be in a better position to judge the accuracy of the comparison he seeks to draw between the two lamps.

Short Notes on Illuminating Engineering.

From all Sources.

Effects of Good Factory Lighting.

SEVERAL speakers in a recent discussion on factory lighting at a meeting of the Illuminating Engineering Society in the United States bore emphatic witness to the benefits that good illumination conferred.

Thus Mr. C. W. Price remarked :—

"One of the largest co-operations in the United States, which has done the most successful work along the line of protection against injury, emphasizes very strongly the value of light.... In 1900, 43 men out of every 100 employed by the company were injured and lost time, with a total of some 10,000 employees. In 1909 the number was reduced to 19 men out of every 100 who were injured and lost time. The superintendent would say that good lighting had had an important part in this result."

Another matter referred to was the importance of keeping lamps and fixtures clean and Mr. Newman added that the International Harvester Co. employed two and sometimes more men constantly cleaning globes and reflectors.

Indirect Lighting in a Theatre.

ONE of the latest applications of indirect lighting is the new installation at the Plaza Theatre in Chicago, which was recently described in *The Electrical Review*, N.Y. The entertainment provided at this theatre is of the vaudeville type, and it is usual to keep the building lighted throughout the performance ; hence great importance was attached to obtaining a light as restful and free from glare as possible. To attempt this with the usual multiplicity of small incandescent units would have added to the complexity of the wiring and led to additional expense. For these reasons the indirect system of lighting was adopted.

There are nine main fixtures lighting the ceiling of the building, with a total consumption of 4,800 watts, and giving a calculated illumination on the seats of 2·3 foot-candles. A number of smaller units are employed under the balcony and in other parts of the theatre, and in the entrance lobby a departure was made from the absolutely indirect system, a canopy, containing six 100-watt lamps with indirect reflectors and an opal ceiling bowl in the centre, being used. Round the edge of the canopy are 18 pendant frosted lamps which provide the direct lighting, and the whole is said to form a very attractive fixture.

Lights under Water in a Swimming Bath.

THE managers of a Swimming Bath in Chicago have, according to *Popular Mechanics*, recently installed a row of electric lamps at the bottom of the deepest part of the bath, as a safeguard against the danger of drowning, should the swimmer get into difficulties when diving or swimming under water. The installation consists of six Tungsten lamps, 32 c.-p., fitted with water-tight glass covers. It is suggested that no accident could now pass unnoticed, as a swimmer can easily be located all the time he is beneath the surface.

Co-operation in Street Lighting.

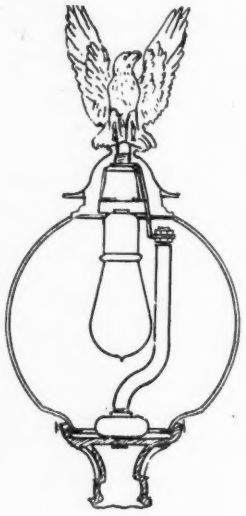
"A REPRESENTATIVE or representatives of the city should be appointed to confer with representatives of the Sanitary District and of the other governing bodies interested, and should draw up a plan which would reduce expenditures for electric light and power to the lowest possible terms. It seems probable that very large savings could be effected by this means, and no time should be lost in formulating plans for this purpose."—Extract from Report of Chicago Commission on City Expenditures, referring to Street Lighting.

Eyesight and the Detection of Fire-damp.

IN a recent paper before the Royal Society of Arts, Sir Henry Cunynghame referred to the method of detecting fire-damp in mines by the appearance of a cap on the flame of the Davy lamp, and emphasized the importance of good eyesight to the miner, in order to enable him to distinguish the cap even when only faintly visible owing to the small amount of fire-damp present. A suggestion was made in the discussion which followed, that examination of the sight of all responsible persons in mines should be made compulsory. An important feature, Sir Henry pointed out, was the distinction between the illuminating function of the lamp and its use to detect fire-damp. In the new lamp exhibited, a permanent strong electric light, fed by a battery, was provided. In addition there was the flame, necessarily small and dim, which served for fire-damp detection. The electric lamp could be switched off while testing the air. Before this modification had been introduced, miners suffered from the inconvenience that the small test-flame not only gave a very feeble light but was liable to be extinguished by a slight gust of air. He had found the addition of sodium carbonate serviceable in giving the flame a yellow tint and making its change more distinct.

An Ornamental Standard for Tungsten Lamps.

A NEW installation of tungsten street lamps in one of the principal thoroughfares of Washington, U.S.A., has afforded an opportunity for the introduction of a novel ornamental design of lamp standard, which was referred to in a paper by Mr. A. J. Marshall before the New York Section of the Illuminating Engineering Society.



The upper part of the lamp is shown in the above diagram. The lamps are suspended in a ground-glass globe, 15 in. in diameter, and are supported by an insulated bent piece, which is arranged on the side of the lamp turned toward the houses. The lamp at the centre of the globe is about 10 ft. from the ground, and the posts are spaced about 60 ft. apart. Each standard is surmounted by a representation of the American eagle. In parts of the road which are most frequented and where the foliage on the sidewalks is somewhat dense, 80 c.-p. lamps are installed, while for the remaining portions 40 c.-p. per lamp is considered sufficient.

Neon Vacuum Tube Lighting.

In a recent communication to the *Académie des Sciences*, M. Claude describes how he has brought into practical form for lighting purposes, a vacuum tube containing neon. This has all the more interest in view of the fact that the front of the Grand Palais in the Champs Elysées was lighted by means of these tubes during the recent automobile show, the installation, comprising four tubes each 36 metres long, being carried out by the Moore Light Company.

One of the chief difficulties met with in constructing tubes of this kind was the fact that a very small trace of certain other gases will neutralize the effect of the neon, for example, a few hundredths per cent of nitrogen would reduce the lighting power very greatly. It was of no use, therefore, merely to introduce neon into the tube, even in a very pure state, for the gases liberated from the electrodes on the passage of the current would immediately neutralize its effect.

A method has been adopted of overcoming this difficulty which depends on the fact that neon is less easily liquefiable than the other gases concerned, and therefore, according to the discovery of Dewar, it is less readily absorbed by carbon at low temperatures such as that of liquid air. Hence, by using carbon receivers welded to the tube and immersed in liquid air, all other gases except the neon (and a little hydrogen) are absorbed, and after prolonged treatment, the neon becomes pure enough to produce its characteristic light.

The light thus obtained is very rich in red rays, being the exact opposite of that from mercury vapour lamps, and it is stated that the eye accustoms itself very readily to the light, which gives an impression of golden yellow.

As compared with the nitrogen Moore tube, the voltage required at the terminals is much smaller, being only 1,000 volts, and, as is usual with arc discharges, the voltage diminishes with increase of current. The power factor works out at 0·9 a similar figure to that of the Moore tube, and the efficiency when considering only the power absorbed in the tube and neglecting the loss in the transformer, &c., was found to be 0·64 watts per candle.

These results were obtained on an experimental length of only 6 metres, and it is pointed out that, as most of the loss occurs at the terminals (in this case it was estimated that about 300 watts out of a total of a 1,000 were lost in this way) much better results would be obtained in very long tubes, where a larger proportion of power would be usefully employed.

Torches in Shopwindows.

The accompanying illustration, which we reproduce from *Popular Electricity*, shows a device introduced by a German firm for attracting attention to shop-windows. The idea is to reproduce as closely as possible the effect of a flaming torch. This is done by using an opalescent glass globe moulded in the shape of flames and illuminated from inside with a number of small glow-lamps of different colours. To obtain

the flickering effect some of the lamps remain lighted continuously while others are lighted and extinguished in quick succession. Whether the imitation is sufficiently realistic to deceive passers-by or not, it should prove an attractive device, and has not the element of danger which makes the use of real flames undesirable.

Illumination in China.

An article under the above title, recently appearing in the *Revue des Eclairages* refers to the change which has come over methods of illumination in China during the last forty years.

Lighting, it is pointed out, in one sense plays a much more important part in the life of the people of China than it does in Europe. So much intercourse, both for business and pleasure, takes place after dusk, that some form of illuminant must be carried by every self-respecting Chinaman when he walks the streets, for public lighting is practically unknown in China.

Lanterns have been from time immemorial the universal illuminant, used by all classes of society. Their price ranges from less than a farthing to five or six shillings, and it is largely by the style of the lantern that he carries, that one judges the social status of a Chinaman. Again, there is a very extensive use of lanterns for special illumination on the occasion of a national festival, or even when celebrating the birthday of the head of a household.

When one considers the enormous population of China, it is clear that the extended use of lanterns indicated above must provide a large market for illuminating oils, candles being much too dear for the average Chinese income. It is in this direction that a great change has come about in the last twenty or thirty years.

From the earliest times, vegetable oils have been the staple illuminant of China, on account of the ease and cheapness of production. But, since 1866, a new product has come into competition with the native oils in the shape of petroleum. It is probable that mineral oil was introduced into the country by the Chinese employees of European firms; then, slowly at first, but latterly at a very rapid rate, it has almost monopolized the Chinese market.

The importation of petroleum into China, which was in 1872 231,000 gallons, was recently estimated to be over 120,000,000 gallons in a year. This has largely been brought about by the enterprise of the Standard American Oil Company, who have made most elaborate arrangements for the supply of petroleum in the Empire, but they are by no means the only vendors in the field at the present time.

It is interesting to note that the importation of mineral oils into China has resulted in a largely increased exportation of the native vegetable oils, a natural consequence of the diminished sale of the latter in local markets. Other influences have, of course, been at work in producing this result, such as the development of railways and navigation, and the general opening up of the country, but it seems reasonable to attribute it in some measure to the growing use of mineral oils for illuminating purposes.

A Portable Electric Light Fixture.

An adaptation of the principle of the flexible steel tape measure to a portable electric lamp is mentioned in a recent number of *Popular Mechanics*. The steel tape is replaced by a considerable length of ordinary flexible lamp cord, and the reel case is fitted, on the opposite side to the usual winding handle, with a standard lamp-holder. The free end of the flexible wire is fitted with an adaptor which can be fitted in any existing lamp-holder, whilst the reel with a lamp attached can be moved to any required position. The advantage of this arrangement is that whatever length of flexible is used, the surplus wire is always neatly wound up out of the way.

An Electric Kite.

One of the most striking features of the illuminations in connexion with the Electrical Exhibition at Denver, Colorado, last October, was a representation of Franklin's kite, which was completely outlined in glow-lamps down to the "string" which held it to earth, and soared proudly over the highest buildings.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Automatic Lighting of Street Lamps.

The lighting of street lamps from some central point of control by the effect of a rise of pressure to some predetermined figure has been in use for some time past, but the BROADBERRY APPARATUS recently introduced by the **Telephos Domestic and Street Lighting Co., Ltd.** (16–20, Farringdon Avenue, E.C.), is stated to have the great advantage that it discriminates between a slow rise of pressure, which might be accidental, and the rise intended to work the apparatus, which is given quickly from the point of control. This effect is obtained by means of a float pierced with a small hole and surrounded by a vessel containing water. When under the influence of a slow rise of pressure the outside level of water is slowly raised, it has time to percolate through the hole in the float, and therefore does not raise it. If, on the other hand, a sudden and considerable rise of pressure takes place, the level of water rises suddenly and carries the float with it, allowing the latter to actuate the gas-valve leading to the operating chamber.

The Tilley High-Pressure Gas Syndicate (53, Kingsland Road, N.E.) send us particulars of their system, in which a compact and well-designed gas-compressor is one of the principal features. No gas storage reservoir is required, and the valve can be easily regulated from outside, and while the plant is running, by means of weights in the valve-chamber. For lighting, a pressure of from 54 to 60 in. is used, and the arrangement is such that, when the compressor is stopped, low-pressure gas is supplied to the system without any bye-pass arrangement.

Inverted lamps have been specially designed for use with this system, and it is claimed that an efficiency of over 50 candles per cubic foot can be obtained by the use of any of these, whilst with the best combination of lamp and suitable pressure as much as 60 candles per cubic foot is said to have been obtained.

The "Union Economic" Arc-Lighting System.

IN these columns we have frequently referred to the Union Excello arc-lamps of the **Union Electric Co.** (Park Street, Southwark, S.E.). The "Union Economic" system of lighting is a special combination of Excello flame arc-lamps and Kohinoor enclosed arcs. The method is intended to utilize the line voltage as efficiently as possible with a minimum loss in heating the line-resistance, and is specially adapted to shop lighting.

Two Excello flame arcs, each consuming 10 amperes, and two Kohinoor enclosed lamps, taking 5 amperes, are used. These (and the necessary line-resistance) are so connected that by simply throwing over the switch one can secure either of the two following combinations :—

1. The current flowing first through the two Excello flame arcs in series, and then through the two Kohinoor lamps in parallel.

2. The two Excello lamps out of circuit and the two enclosed arc-lamps in series only in use.

The advantage of the method for shop lighting is that the two powerful flame arcs can be used outside for spectacular purposes, and the two enclosed arcs for interior lighting. When desired one can throw over the switch and put the flame arcs out of circuit, retaining the enclosed arcs indoors, and consuming only half the current. The essential point in the system is that in either case the lamps are used on the usual circuit pressure of 200–220 volts under the most economical conditions.

The United Kingdom Lighting Trust (231, Strand, London, W.C.), send particulars of the MORTON GAS PRODUCER PLANTS. Gas generated is stated to compare very favourably with town gas, even at one-sixth per 1,000 cubic feet. The quality of the gas is illustrated by an indicator diagram showing twenty consecutive cyles.

Arc Lamps.

The "BUTT" ARC LAMP is described in a pamphlet received from the **General Electric Co., Ltd.** (67, Queen Victoria Street, E.C.). One of its chief features seems to be the absence of complex working parts. The efficiency is claimed to be 0·15 watts per candle; it is pointed out that for alternate current working only one mineralized flame carbon is required, with a consequent saving in carbon cost.

Messrs. Crompton & Co., Ltd. (Salisbury House, London Wall, E.C.), have also sent us a very complete catalogue of their well-known OPEN, ENCLOSED AND FLAME ARC LAMPS.

THE accompanying illustration shows an inverted form of the DAVY 'SUNRAE' FLAME ARC LAMP, fitted with a reflector in order to obtain indirect light where freedom from shadows is required. A feature of this lamp is the simplicity of the mechanism, no shunt core being needed.

We understand that the manufacturers, **Messrs. Arc Lamps, Ltd.** (St. Albans, Herts.), have supplied a large number of Enclosed Arc Lamps of this inverted type for use in drawing offices and factories. We have also to acknowledge the receipt of particulars of other varieties of arc lamps and accessories made by this firm.

The Electrical Trades Supply Co., Ltd. (Britannia Works, Gt. Charles Street, Birmingham) send us particulars of insulating materials, ironwork, jointing materials, insulating tapes, &c.

Electrical Supplies.

FROM the **British Westinghouse Manufacturing Company, Ltd.,** (Westinghouse Buildings, Norfolk Street, Strand, London, W.C.), we receive an abridged catalogue of Electrical Supplies (No. 201). The list contains full particulars of lamps of all kinds, including the "ARCTURUS" ENCLOSED ARCS and the most recent form of mercury vapour lamp provided with an electromagnetic rocking device. Details are also given of various accessories, and a special section is devoted to HOLOPHANE globes and reflectors, &c. An additional leaflet from the company describes the enamelled resistance units, a specially compact form of experimental resistance for experimental and arc-lamp circuits, motor starters, &c.

WE have received from the **Electric Motor and Equipment Co.** (Newark, N.J.) a short pamphlet dealing with the "G M" LAMP, a scientifically designed table lamp, to which we had occasion to refer in a former issue.*

The British Thomson-Houston Co. (83, Cannon Street, E.C.) send us an illustrated list, showing the various types and ranges of "MAZDA" LAMPS manufactured at their Rugby works.

Among various pamphlets from the **Linolite Co.** (25, Victoria Street, S.W.) we notice illustrations of their TUBOLITE (pattern B) TABLE LAMP, and also a form of fitting suitable for a roll-top desk.

The Electrical and Engineering Supplies Co., Ltd. (36–37, Upper Thames Street, E.C.), send us a list showing a great variety of flashing and other signs, and devices for illuminating purposes. They also supply a simple and inexpensive type of flasher which depends for its action on the alternate expansion and contraction of a strip of metal.

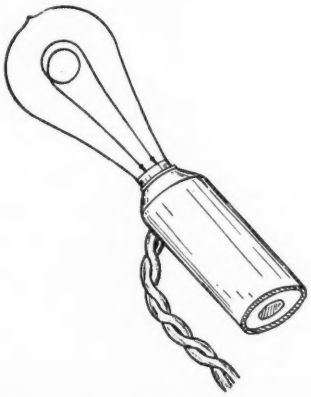
Messrs. Siemens Bros. Dynamo Works, Ltd. (Caxton House, Westminster), who are agents for the "WATKIN" SWITCH, have sent us a booklet with illustrations and descriptions of the many applications of this switch, which, by making it possible to vary at will the amount of energy supplied to a lamp or heater, is stated to effect a very considerable saving.

The contracts for the supply of metal filament lamps to the L.C.C. Tramway and Stores Department and the Royal Mail Steam Packet Co. have, we are informed, been placed with **Messrs. Siemens Bros. Dynamo Works, Ltd.**

* *Illum. Eng.*, vol. iii., Sept., 1910, p. 579.

A Magnetic Lamp Holder.

The lamp holder shown in the accompanying illustration is an ingenious combination of socket and electro-magnet which enables the lamp to be fixed at any angle on a surface of iron or steel, by simply placing it where it is wanted. The magnet is wound separately from the lamp circuit, so that if the lamp is broken or removed from the socket the holder does not fall to the ground. The



manufacturers, the **Federal Electrical Company** of Chicago, have wired the holders for several typical voltages, from 110 volts for ordinary purposes down to 6 volts which might be useful in connexion with sparking batteries.

THE Electrical Department of the **Thames Iron Works, Shipbuilding, and Engineering Co., Ltd.** (Canning Town, London, E.), have sent us a very complete catalogue of their switch specialities. We may make special mention of their watertight form of ordinary SNAP SWITCH; the firm also lists a watertight combined PLUG AND SWITCH which has been designed especially with a view to use in mines, factories, steamships, &c.

Messrs. William Geipel & Co. inform us that they have recently executed some large orders for their STEAM TRAPS, particularly the "Rapidity" type, which, on account of its many advantages, is replacing older types.

Other Lists received :—

The General Electric Co., Ltd., (71, Queen Victoria Street, London, E.C.).—Electro medical apparatus.

Messrs. Isenthal & Co. (85, Mortimer Street, London, W.).—Klingelfuss electro medical switchboards and vibrators.

British Central Electrical Co., safety fuses and plugs, &c.; **Messrs. W. T. Glover & Co., Ltd.,** ribbed steel tape armour for cables; **Messrs. A.E.G. Co.,** measuring instruments; **The British Westinghouse Electric and Manufacturing Co., Ltd.,** ammeters, voltmeters, and motor control boxes; **Messrs. R. & J. Beck, Ltd.,** optical and microscopic apparatus.

Station Lighting by Tantalum Lamps.

VIBRATION is not now considered such a serious objection to the use of metallic filament lamps as was formerly the case, and the accompanying illustration shows one of several railway stations in which TANTALUM LAMPS have recently been installed by **Messrs. Siemens Bros. Dynamo Works, Ltd.** (Tyssen Street, Dalston, N.E.). They have stood well the severe vibration, and it is interesting to note that other stations will be similarly equipped in the near future.

The Manufacture of Tungsten Lamps.

A VISIT TO THE IMPERIAL LAMP WORKS (BRIMSDOWN).

A VERY interesting entertainment was provided for those visitors who had the privilege of seeing over the Imperial Lamp Works at Brimsdown on January 20th.

Until recently the details of manufacture of metallic filament lamps have been guarded as secrets by most companies, and it was therefore very fascinating to be allowed to watch the stages of production right up from the raw material to the final product in these new works in which a high standard of efficiency seems to have been attained. The organization is such that in passing through the various rooms one sees, in regular sequence, the production of the colloidal material from which the filament is prepared, its squirting, drying, passage through the roller press, and moulding into ductile homogeneous filaments as fine as 0·0025 mm. diameter, and then the delicate processes of mounting in the bulb.

An additional item of interest from the illuminating engineering standpoint was the brightness and orderly cleanliness of the various rooms; the arrangements for ventilation are also exceptionally complete, warm, filtered air being regularly supplied from a special plant for the process. The greater number of the operators are girls, their delicacy of touch being essential in many of the finer processes to which the filaments are subjected. It was stated that the operators have improved considerably in dexterity since the works were opened, the percentage of breakages having now been reduced to under 15 per cent. The details of manufacture, in short, are now standardized. It seems but the other day we were greeting the first metallic lamps with amazement, and lo! their production in large quantities in this country is already becoming an accomplished fact.

The Iron and Steel Institute.

THE ANDREW CARNEGIE RESEARCH SCHOLARSHIP.

This is awarded annually, irrespective of sex or nationality, on the recommendation of the Council of the Institute. Candidates, who must be under thirty-five years of age, must apply on a special form before the end of February to the Secretary of the Institute.

Beckenham Electricity Exhibition.

THE Electricity Department of the Beckenham Urban District Council is opening a permanent exhibition and showroom at 45, High Street, Beckenham, in order to display to the best advantage the many applications of electricity to domestic lighting and heating.

Rooms have been furnished and decorated to represent dining-room, kitchen, &c., and in these are assembled a large variety of fittings which are all shown in actual use, and effectively demonstrate the wide field for electricity in the home.

Mercury Vapour Lamps for Factories.

WE have received from the **Westinghouse Cooper Hewitt Co., Ltd.** (151–152, Great Saffron Hill, London, E.C.), a pamphlet describing a very large installation of mercury vapour lamps in the "Stehli" Silk Mill (U.S.A.). Details are given of the illumination and the power consumed in obtaining it.

Robertson Electric Lamp Works.

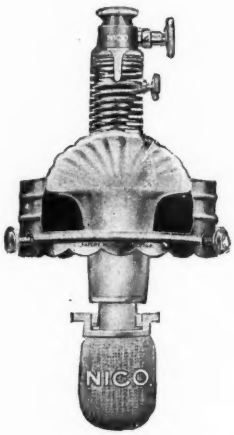
A FANCY dress dance was held in connexion with the above works on Saturday, January 14th, when about 300 persons were present, and a successful evening concluded with a presentation of prizes by Mrs. C. Wilson.

MR. H. THURSTON OWENS, Consulting Engineer, New York City, has been appointed Associate Editor of *The American Gas Light Journal*, 42, Pine Street, New York City. Mr. Owens has been connected with the lighting industry for the past ten years, and has been a frequent contributor to the technical press. He is quite active in association work, being a member of the American Gas Institute, National Commercial Gas Association, New York Electrical Society, the U.S. Illuminating Engineering Society, and a corresponding member of the British Illuminating Engineering Society.

WE have received particulars from the publishers (32–36, Fleet Lane, Old Bailey, London, E.C.) of the GAS ENGINEER'S ANNUAL DIRECTORY OF GAS UNDERTAKINGS FOR 1911.

The New "Nico" Lamps.

The **New Inverted Incandescent Gas-Lamp Co. Ltd.** (19 and 23, Farringdon Avenue, London, E.C.), have sent us particulars of two novelties in inverted lighting. The 'Nico-Vibra' burner, which we illustrate here, has, as its main feature, an anti-vibration device, consisting of a hardened steel spiral spring which forms the connection between the burner and the nipple. Inside the spring, the gas is carried by a funnel working in a bottom tube having a bell-mouth. Owing to the conical shape of the funnel, moving it up or down



enlarges or reduces the annular space between it and the surrounding tube, thus ensuring a fine adjustment of the air supply. There is also an air supply at the top of the funnel, and this combination is claimed to produce a noiseless and high-temperature flame under widely varying conditions.

The other novelty is the 'Nico-Radio' Lamp for Outside Lighting, the main features of which are that it is self-intensifying, is fitted with external air and gas regulation, and is proof against wind and rain. A Parabolic Reflector can be supplied when these lamps are used for shop-window lighting.

The Centenary Gas Co. (109, Hope Street, Glasgow) have sent us a list dealing with their TURBINE PETROL-AIR GAS GENERATOR, and the various fittings they supply for use with this system.

The **Sturtevant** system of heating and ventilating factories and other large premises, is dealt with in an illustrated pamphlet received from the **Sturtevant Engineering Co., Ltd.** (147, Queen Victoria Street, E.C.).

We have received a very complete descriptive price list of LANTERNS AND PROJECTION APPARATUS for various purposes, from **Ferdinand Ernecke** (4, Ringbahnstrasse, Tempelhof, Berlin).

The New Mansfield Inverted Incandescent Gas Burner.

As we go to press we receive from **Messrs. Mansfield & Sons, Ltd.** (Derby Square, James Street, Manchester), particulars of their new inverted gas burner which is stated to have several distinctly new features, on which we hope to comment in greater detail shortly.

It will be recalled that in the discussion of Mr. Goodenough's paper before the Illuminating Engineering Society special reference was made to the need for a burner which could be readily applied to the efficient use of any quality of gas, and to the varying requirements of different districts, without inconvenient and troublesome forms of adjustment. For the burner to which we now refer, it is claimed that this can be readily accomplished; moreover, it is stated that the burner can also be designed for consumptions from ½ to 5 cubic feet of gas per hour, and that 20 to 30 candle-power per cubic foot can be obtained according to the local quality of gas available.

Forthcoming Lectures.

The course of six lectures on Illumination, now being delivered by Mr. J. S. Dow at the Westminster Technical Institute (Vincent Square, S.W.), will be completed on Fridays, Feb. 3rd, 10th, and 17th, at 7.30 P.M.

A course of twelve lectures on 'Electrical Costs and Quantities' are to be delivered by W. Brew, M.I.E.E., at Battersea Polytechnic on Thursday evenings, commencing on January 19th, at 7.30.

Two lectures on 'Colour Vision and Colour Blindness' are to be delivered by Prof. F. W. Edridge-Green, M.D., at the Royal College of Surgeons on February 1st and 3rd, 1911, at 5 P.M.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

DURING the past month there have been many articles in the nature of a review of the past year. The editorials in the British papers deal chiefly with recent discussions of the Illuminating Engineering Society: a special account of the doings of the Society is given in the *Electrical World* for Jan. 12th.

A question which continues to excite comment in the United States is **Colour-Value in Illuminants.** Thus *The Electric World* refers to the growing recognition that this is a matter for settlement at an international photometrical convention, and under the title 'What is Daylight?' points out how daylight illumination varies in colour in different circumstances.

In discussing progress of the year special mention is also made of the growing desire in the United States for **Decorative Displays of Light** and the value of illuminants on special colour-tint. A notable example is the Allegheny County Soldiers Memorial Building, which was described by W. BASSET JONES before a recent meeting of the Illuminating Engineering Society (U.S.A.). Here the use of a mosaic of diffusely transmitting coloured glass, with flame arcs above it, and the special employment of pink Moore tubes and mercury vapour lamp screened by blue glass, is said to give rise to most novel and striking decorative coloured effects.

A variety of illustrated articles in *The Illuminating Engineer* of New York, deal generally with the lighting of various buildings a specially interesting item being the **Illumination of a Large Steamship Pier.** The same journal gives prominence to a campaign now being undertaken in the United States with a view to **Improving the National Vision;** the defects in this respect are looked upon as being closely connected with deficiencies in illumination, and these are being steadily improved. One other very interesting article of a physiologic trend is that in the *Zeitschrift für Beleuchtungswesen* summarizing a discussion, in which Voege, Stockhausen, and others have played a part, regarding the **Effect on the Eyes of Ultra-violet Rays** and the best type of protective glasses; incidentally some interesting information is given regarding solutions for filtering out different regions of the spectrum. *Il Gaz* (November, 1910) and the *Revue des Eclairages* (Jan. 15th) also comment upon the hygienic aspects of illumination.

Among articles of a more theoretical nature we may note the interesting researches on **Diffuse Reflection** from different materials published by F. H. GILPIN in the December number of the *Transactions* of the American Illuminating Engineering Society. He brings out the importance of the angle of incidence as affecting reflective power, and also summarizes the results in terms of the total amounts of light striking the surfaces studied and reflected therefrom.

E. DYHR (*E.T.Z.*, Dec. 23rd) gives the results of some tests on the **Accuracy of the Globe-Photometer,** undertaken at the suggestion of Ulbricht. These seem to have been intended to study the extent of several sources of error, such as the selective absorption of the inner white coating of the globe, the imperfect diffusing properties in the observation window glass, &c., which were pointed out in W. E. Sumpner's recent paper before the Illuminating Engineering Society (London). The experiments seem to show that the errors alluded to have only a slight influence in practice; on the other hand the author expresses the view that the cubical box, advocated by Sumpner would not give accurate results with many sources.

E. L. NICHOLS (*T.I.E.S.*, December) gives some interesting particulars of the **Early History of Standards of Light** and A. P. TROTTER (*Electrician*, Jan. 13th) describes some tests on **Accumulators for Portable Photometers,** in support of his contention that adequate accuracy may be secured without measuring the current; this point was recently raised by C. H. Sharp in the same journal.

ELECTRIC LIGHTING.

Many of the articles on electric lighting summarize progress in some department during 1910. L. BELL, in doing so refers to improvements in the magnetite arc, now made for higher currents; the titanium arc-lamp seems to be less favoured at the moment. There is, however, need for a good "luminous" arc for alternating currents.

In response to a letter from C. H. Sharp, C. L. KINSLOE gives further data regarding his experiments on the **Effect of Waveform on Incandescent Lamp Efficiencies** (*Elec. World*, December). The same matter is dealt with theoretically by M. LLOYD (*Elec. Rev.*, Jan. 14). He finds that when the filament temperature lags slightly behind the current the power taken, with a direct current, by metal lamps is greater than with alternating current. In the case of carbon filament lamps it is *less*. But in both cases the candle-power will be greater than on a direct supply of the same voltage and again greater with a peaked wave than with a flat-topped one. Only experience can decide how life-tests in the two cases vary; but the present data are inconclusive.

In connexion with incandescent lamps we may note the reference in the *Journal für Beleuchtung* to the **"Wotan" Lamp,** a German lamp, in which a drawn wire tungsten filament, having the efficiency of the best tungsten and the durable method of winding hitherto until recently only associated with tantalum. H. D. WILKINSON writes criticizing forms of switching devices which only reduce candle-power by introducing resistance, and thus work the filament at a very low efficiency

K. EDGCUMBE gives some photometrical measurements of the illumination in Gower Street. He finds the electrical lighting gives greater uniformity than the gas lighting. The *Zeitschrift für Beleuchtungswesen* describes the **Hrabowski Reflector for Arc-Lamps** which has been previously described in these columns* and presents a photograph showing the improved distribution of illumination which is said to be secured.

GAS, OIL, ACETYLENE LIGHTING, &c.

Here again we find a number of articles summarizing progress in 1910; *The Journal of Gas Lighting* (Dec. 27th) has a valuable retrospect, and PICKERING (*J.G.L.*, Jan. 17th; *G.W.*, Jan. 21st), in a recent address, deals more especially with gas lighting. An interesting feature in this paper is the use made of data given by F. W. Goodenough in his recent paper before the Illuminating Engineering Society, and other information from the same source.

An interesting paper, by J. H. COSTE and W. E. F. POWNEY, deals with the question of framing a **Standard Specification for Mantles.** The suggested test would include measurements both of candle-power and shock-resisting ability, although some difference of opinion still exists as to what form and frequency the shocks should assume.

Other contributions deal with **Automatic Distance-lighting.** Thus LUX (*J.f.G.*, Dec. 27th, 24) deals with electrical methods and GRIX (*J.f.G.*, Dec. 31st) describes the application of his self-lighting system to inverted burners. This presents special difficulties and the author describes how they are overcome by arranging for the pellet of platinum to be withdrawn from the heat of the flame after ignition. He adds that the device was used for 67 days, in the course of which 443 kindlings took place, without any appreciable deterioration. Recent numbers of *The Gas World* and *The Journal of Gas Lighting* summarize the good results obtained in Newcastle by the use of the Alder and Mackay and Bamag pressure distance lighters, a considerable economy being stated to have accrued.

Special mention should finally be made of a paper by J. PATTISON (reproduced in *Acetylene*) dealing with **Marine Lighting.** The early part of the paper contains a summary of the available systems of acetylene, Pintsch gas, oil-gas, &c., and the qualifications of a good light for buoys in distant inaccessible places are discussed. It is interesting to note that for penetration of the atmosphere it is *intrinsic brilliancy* rather than candle-power that is demanded.

* *Illum. Eng.*, Lond., July, 1910.

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A notable Innovation in Lighting (*Elec. World*, N.Y., Dec. 15).
What is Daylight? (*Elec. World*, N.Y., Dec. 22).
Tungstens *v.* Welsbachs for Streetlighting (*Elec. World*, N.Y., Jan. 5).
Progress in Electric Lighting (*Elec. World*, Jan. 5).

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Peculiarities in Diffuse Reflection (*Elec. World*, Jan. 5).
Special Treatment in Illumination (*J.G.L.*, Jan. 24).
Lighting of Public Libraries (*G.W.*, Jan. 21).
Gilpin, F. H. Variations in Reflecting Power with the Angle of Incidence (*T.I.E.S.*, Dec., 1910).
Grimshaw, R. Lighting of Large Halls (*Illum. Eng.*, N.Y., Jan.).
Newman, J. Factory Lighting (*T.I.E.S.*, Dec.).
Nichols, E. L. Early Standards of Light (*T.I.E.S.*, Dec.).
Pierce, R. F. Street Illumination in Germany (*Illum. Eng., N.Y.*, Jan.).
Tuerk, F. S. Lighting a Steamship Pier (*Illum. Eng.*, N.Y., Jan.).
Trotter, A. P. Accumulators and Portable Photometers (*Electrician*, Jan. 13).
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L'Igiene dell' Illuminazione (*Il. Gaz.*, November, 1910).
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Comparative Costs of Different Illuminants (*Elec. World*, N.Y., Dec. 29).
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Bell, L. The Lighting Situation (*Elec. Rev.*, N.Y., Jan. 7).
Edgcumbe, K. The Experimental Lighting in Gower Street, London (*Electrician*, Jan. 20).
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Effects of Waveform on Incandescent Lamps (*Elec. Rev.*, N.Y., Jan. 14).
Kinsloe, C. L. Voltage Wave Distortion and the Life of Incandescent Lamps (Corres., *Elec. World*, N.Y., Dec. 15).
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Wilkinson, H. D. " Turning Down " Electric Lamps (*Electrician*, Jan. 6).
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Die Wotanlampe (*J. f. G.*, Dec. 24).
The Electric Equipment of the Palladium (*Electrician*, Jan. 20).
Electric Illumination and Luminous Efficiency (*Elec. Rev.*, N.Y., Jan. 7).
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Total reflektor, System Hrabowski für offene Bogenlampen (*Z. f. B.*, Jan. 20).
Tantalum Lamps in Chicago Railway Cars (*Elec. Railway Jour.*, Dec. 17).

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Coste, J. H., and Powney, W. E. F. Testing Incandescent Mantles (*J. G. L.*, Jan. 10).
Editorials. A Retrospect (*J.G.L.*, Dec. 27).
A Quality Test of Incandescent Mantles (*J.G.L.*, Jan. 10).
Grix, W. Platin-Gasselbstzünder für hängendes Gasglühlicht (*J. f. G.*, Dec. 31).
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How to choose an Air-gas Plant (*Domestic Engineering*, December).
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Éclairage Intensif par le Petrole , la Lampe Kitson (*Rev. des Eclairages*, Jan. 15).
Newcastle Automatic Lighting (*J.G.L.*, Jan. 10).
Lowering Gear for Large Lamps (*G.W.*, Jan. 14).
Neuere Verfahren zur Herstellung von Gasglühlampen (*Z. f. B.*, Jan. 20).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
J. G. L.—*Journal of Gaslighting.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society* (*United States*).
Z. f. B. —*Zeitschrift für Beleuchtungswesen.*

Some Publications Received.

The Practical Electrician's Pocket Book for 1911. (S. Rentell & Co., Ltd., 36, Maiden Lane, Strand, W.C.)

The Architects' and Builders' Pocket Book for 1911. (Messrs. E. and F. N. Spon, Ltd., 57, Haymarket, London.)

The Physical Review. This number contains the results of further experiments by Prof. E. L. Nichols and E. Merritt on the subject of Luminescence; G. W. Stewart determines the relation between illuminating power, density, and viscosity of kerosene oils.

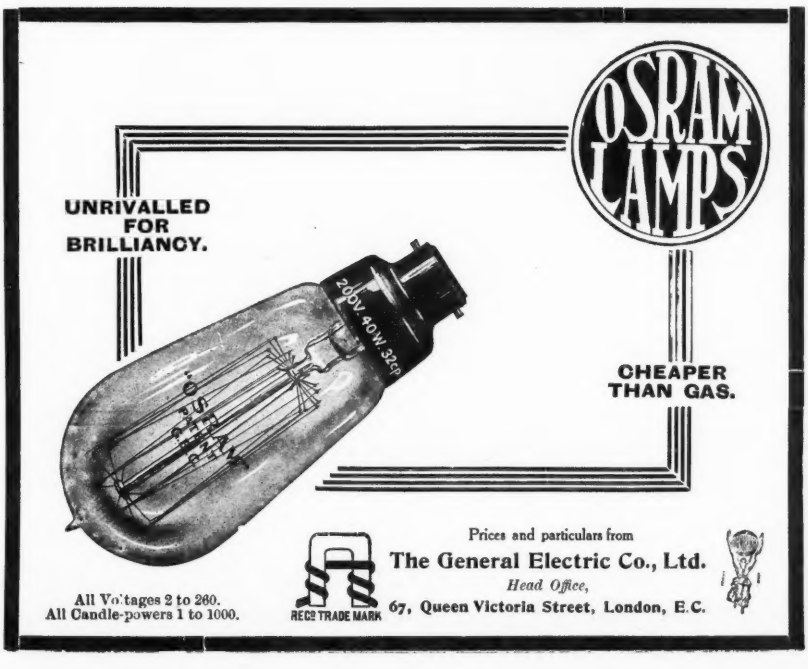
Analyse sommaire du II^e Congrès International des Maladies Professionnelles. A brief summary of the papers at the recent Congress in Brussels.

Zeitschrift für wissenschaftliche Photographie, Photophysik und Photochemie. This contains a large number of spectro-photometric results in connexion with the Emission and Absorption of Luminous Gases subjected to a high-current density.

Annuaire International de l'Acetylene. A summary of progress in acetylene lighting during 1910.

Among other publications we have also to acknowledge the receipt of the following: *Proceedings of the American Institute of Electrical Engineers, Transactions of the American Illuminating Engineering Society, Proceedings of the Institution of Civil Engineers, Proceedings of the Gas Institute, Report of the Acetylene Convention for* 1910 *(U.S.A.), The Journal of the Royal Society of Arts, The Journal of the Royal Sanitary Institute, The Proceedings of the Physical Society, The Proceedings of the Faraday Society, The Proceedings of the American Academy of Arts and Sciences, The American Chemical Journal.*

(To many of these publications we mean to make fuller reference shortly).



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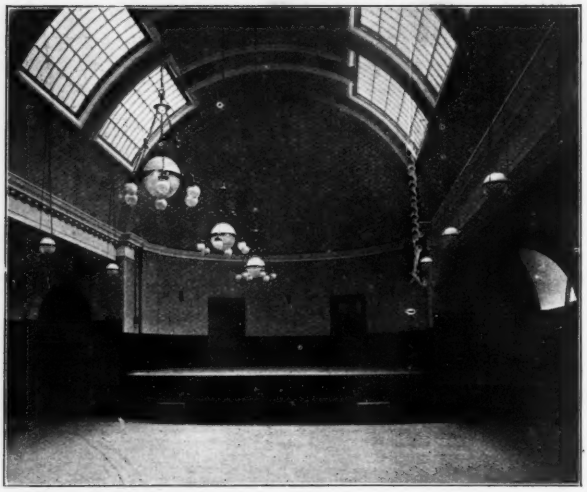

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Edited by LEON GASTER

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EDITORIAL.

Library Lighting—Some Conclusions.

The conjoint meeting of the Illuminating Engineering Society and the Library Association, devoted to the discussion of the problems of library lighting, was concluded on January 31st, and has been the means of presenting to engineers and librarians many points of view which had not hitherto come sufficiently prominently before their notice. It may therefore be of interest to cast an eye over the discussion and see what conclusions can so far be drawn, even if they are to be considered only of a tentative nature. There is much still to be learned, but there are certain points on which agreement seemed possible and to which we should like to draw attention.

Complete Absence of Glare Essential.

In a library nothing in the least wearisome to the eye should be permitted. One of the most obvious defects in some of the installations described in our last number was the exhibition of unshaded bright sources of light. It was pointed out in the discussion that even a casual glance at such unduly bright sources fatigues the eye and prevents distinct vision.

The recommendation may therefore be made (with the more confidence because it is easy to carry out), that in a library *no unscreened unduly bright source, such as a naked metallic filament should be visible to the readers at close range.* Either some form of indirect lighting should be employed or the lamps should be concealed by appropriate shades and reflectors, which both screen the eye and throw the light where it is needed.

Sufficiency of light for reading tables.

The particulars of different libraries, published in our last number serve to show that (excluding a few abnormal cases in which the illumination was clearly deficient), the value for the intensity of illumination on the reading tables was between two and four

foot-candles. This bears out the common experience, and also the exhaustive researches of physiologists on these points that *for the reading of modern print an illumination up to at least 3 foot candles is desirable.* But when specially small print is to be read and the examination of intricate diagrams, parchments, and documents with surfaces of poor reflecting value, &c., is undertaken, provision should be made for a higher value, say of 4—6 ft.-candles, or even more.

General versus Local Lighting.

In selecting the scheme of illumination, the exact nature of the library must be considered. Club reading and writing rooms, public reading rooms, and reference libraries constitute distinct problems. The majority of public reading rooms visited (where casual reading of periodicals, &c., is engaged in) utilize general illumination, and the surroundings are relatively bright. It may be suggested that good general lighting, being usually simpler and less expensive in initial cost, is suitable in such cases. It has several other advantages, namely, that the desks and tables below can be rearranged without interference with the general scheme of illumination; also, since such rooms seem to be as a rule well filled, the production of a uniform illumination over the entire room is not uneconomical; it is, however, desirable to arrange to control the light in sections, so that it is not necessary to light the whole room for some trivial local use.

For reference and student's libraries, where prolonged serious reading is done, the general impression seems to be that a combination of moderate general illumination and adequate local illumination is to be recommended. This method seems to have been adopted with success in a number of reference libraries visited (*e.g.* British Museum, Fulham Library, Patent Office, &c.). The local lamps must be screened from the eye, and the general illumination should also be without glare. The strong local illumination, it is suggested, assists in concentration of the reader's attention, but the contrast with the brightness of illuminated surroundings should not, according to Prof. L. Weber's data on glare, exceed 100 to 1. It appears, however, that this figure was not exceeded or even approached in the majority of libraries visited, and, with an ordinary scheme of decoration, is easily provided against.

It has been stated that local lighting is usually relatively expensive to instal, but, as far as the data available for different libraries enable one to draw a general conclusion, not more expensive in consumption of energy, even assuming that all the lamps are turned on at once. But, inasmuch as many reference libraries are used by comparatively few special students at one time, the benches are often not entirely occupied, and therefore, the fact that light is provided only on those benches where it is required, leads to a saving. One objection to local lighting which deserves consideration, however, is based on the inconvenience of alterations in wiring should the positions of tables be rearranged.

Shelf Lighting.

Two important points brought out in the discussion are (1) *The need for better uniformity in distribution of light over shelves*, and (2) *the need of screening the eyes from the lamp producing this illumination.* The shelf lighting in many libraries proved to be specially defective in the last respect, and this could easily be remedied by the use of opaque reflectors of the trough type. This problem is one on which further results of concrete experiments are badly needed. *It is, however, suggested that an average illumination of not less than 1-1½ foot-candles should be provided on the shelves.*

It may be admitted that the scientific aspects of shelf lighting call for more study than any other branch of

library lighting, and we should like to hear of further experiments on the lines suggested on opposite page.

Shades for Table Lamps.

It would be out of place here to insist upon the merits of any particular make of shade.

It may, however, safely be said that among the chief conditions to be fulfilled by a shade for this purpose are:—the complete screening of the lamp inside from the eyes of the reader; the shade, if not opaque, should allow only a relatively small amount of light to escape through it in a diffused form so as not to cause anything in the nature of glare; it should also be so designed as to produce a sufficiently powerful and uniform illumination, without streakiness, on the table below, and should absorb as little light as possible.

The question of the choice and spacing of such shades forms the special work of the illuminating engineer and the co-operation of the Illuminating Engineering Society and the Library Association will no doubt bear good fruit in this direction. As suggested in our last number we hope that librarians will continue to interest themselves in these matters, and that further experiments on such details will now be made. No doubt on the next occasion when these points are discussed there will be further substantial progress to record.

School Lighting.

The Illuminating Engineering Society, having discussed the subject of library lighting in conjunction with the Library Association, has next turned its attention to the illumination of schools; two very instructive papers on this subject were presented by Dr. James Kerr, Medical Officer (Education) to the London County Council, and Dr. N. Bishop Harman, at the last meeting on February 16. In accordance with the programme of the Society the co-operation of other bodies interested in this problem was again invited, and the Association of Medical Officers in Schools, the Association of Technical Institutions, the Association of Teachers in Technical Institutions, and the London Teachers' Association were all represented in the discussion. The papers by Dr. Kerr and Dr. Harman are reproduced *in extenso* in this number (pp. 154 to 165), and also the written communication from Dr. W. J. Ettles presented at the meeting. The publication of the complete discussion including the remarks of the speakers at this and the succeeding meeting on March 14th will be given in our April issue.

In accordance with the plan previously followed in meetings of the Society the first evening's discussion was devoted mainly to the more physiological aspects of the subject. The technical side of the lighting problem will be dealt with more fully in the adjourned discussion, when additional data on the lighting of various schools and institutions visited will be presented.

The problem of school-lighting has a certain amount in common with the illumination of libraries. In both cases somewhat severe demands are made upon the eyes, and the provision of sufficient reading illumination and the absence of glare are the chief desiderata. There are, however, two features in school-lighting which distinguish the problem from that of illuminating libraries.

In the first place it must be remembered that whereas the presence of a reader at a library, and the seriousness with which he pursues his studies there, are more often optional, attendance at schools is *compulsory*, and a certain degree of diligence is exacted. Clearly, therefore, the provision of a scheme of lighting which is beneficial to the eyes and which aids study *is essential*. The public have an undoubted right to criticize any feature in the arrangement of the lamps which is detrimental to vision and thereby inconvenient to the student.

In the second place it may be re-

called that although many public libraries have juvenile departments, the great majority of the readers are adults; they are therefore less susceptible to injury and better able to take care of themselves than are children in schools, who are often at a critical stage in their physical and mental development. In addition to this the mere effort of study is more exacting in the case of a child to whom the whole process of learning is novel and unfamiliar. Dr. Harman lays stress on this when he remarks: "A normal sighted person of middle age will distinguish characters on paper in a poor light with greater readiness than a small child because the characters are more familiar to the adult. Conversely a child requires a better light to read by than does an adult, to whom reading is a second nature." In fact, if it be conceded (as it must be) that good illumination is essential for the grown-up person to do his work in comfort, this applies, with vastly greater force even, to the case of the growing child.

The two papers before the Society cover a wide field. The question of the provision of daylight illumination alone is one which would provide many evenings' discussions at the hands of the Society without suffering exhaustion. Artificial lighting, with the derived problems of the best means of lighting desks, blackboards, &c., is possibly an even more extensive subject. And when we add to these sections the problem of the measurement of illumination, touched upon by both the authors, there opens out a vista of possible work wider still.

One fact, we think, is made very evident — the need for concerted action between the architect, the medical officer, and the lighting engineer. Co-operation of this kind, we understand, now frequently precedes the design and erection of new schools on the Continent; it would seem that such forethought would be well justified by the fact that so many new educational buildings are constantly being erected.

Another gratifying feature of the discussion at the last meeting was the evidence it afforded of the interest taken in illuminating engineering matters by the educational, medical, and engineering authorities of the London County Council. The special course of lectures on illumination which has just been completed at the Westminster Technical Institute is also an instance of the growing interest in the subject, and the example will, no doubt be followed by other institutions. Grateful acknowledgement must also be made of the courtesy of Mr. Fitzmaurice, the Chief Engineer, Mr. Chas. A. Baker, the Electrical Engineer, and Dr. Kerr, Chief Medical Officer, in granting facilities for visits to be made to various schools under the charge of the London County Council.

We may venture to suggest, therefore, that the papers brought before the Society by Dr. Kerr and Dr. Harman besides proving instructive in themselves, will be perhaps even more valuable in suggesting lines of work for the future and revealing gaps in our knowledge requiring to be filled in by the illuminating engineer and the physiologist. This, it has been seen, was especially true of the papers on library lighting. Some useful general conclusions emerge from this discussion, but a very large number of points requiring further investigation are also suggested. If the Society, at the end of this Session, can look back upon a series of important general questions which it has forced upon the public attention; if it can claim to have brought to light a series of definite problems requiring attention from experts and to have stimulated useful research, it's work has not been in vain. We may safely look to future sessions to take up the threads now being disentangled, and solve in detail the problems thus brought to light.

LEON GASTER.

Review of Contents of this Issue.

THE technical section opens with an article by PROF. H. BOHLE on **The Illumination of Interiors** (p. 133), in which the results of a large number of tests are graphically represented. The influence of various factors, such as colour of walls, distance of lamps from ceiling, &c., on the general illumination of a room is traced out, and conclusions drawn from the curves obtained. Prof. Bohle emphasizes the good results derived from indirect illumination, and shows the important part which light-coloured walls may play in producing uniform illumination on a given test plane.

A brief summary follows of an investigation carried out by NICHOLS and MERRITT in the United States on the variation of **phosphorescence** with temperature. They are able to account in some measure for the complex changes which take place under the influence of varying temperature.

The work of MR. CHARLES F. BRUSH is referred to in a short article on **Photographic Photometry** (p. 139). It is shown how, by taking certain precautions, especially in regard to temperature variations, and by so arranging successive images on a photographic plate as to secure the sharpest possible contrast, a fairly accurate measure can be obtained of a small difference of illumination. The highest accuracy is probably about one per cent.

A brief account of some recent researches of DR. H. E. IVES on the **Radiation of the Fire-fly** follows (p. 140). These latest experiments, which have extended both into the infra-red and ultra-violet regions, serve to confirm the fact that there is no perceptible radiation other than the visible.

The section of the magazine devoted to the TRANSACTIONS OF THE **Illuminating Engineering Society** contains an account of the resumed discussion on **Library Lighting,** followed by a report of the Meeting at which Dr. James Kerr (Medical Officer to the L.C.C.) and Dr. N. Bishop Harman opened a discussion on **School Lighting.**

In the adjourned discussion on **Library Lighting** (p. 144), MR. P. BLAGG and MR. V. G. MIDDLETON both referred to the difficulties experienced by contractors in obtaining information beforehand as to the exact position in which fittings are to be placed, and the consequent haphazard arrangement of fixtures. MR. HAYDN HARRISON suggested the use of white drugget on the floor in conjunction with directive reflectors as a simple method of obtaining more uniform illumination on the shelves than appeared to exist in the majority of libraries. MR. T. E. RITCHIE called attention to the possibilities of indirect illumination as a solution of the shelf-lighting problem, and showed some slides illustrating what had been done by this method in lighting filing shelves, a problem closely allied to that of lighting shelves in a library.

MR. V. H. MACKINNEY described some experiments with Holophane shades which had been carried out in the alcoves of the Patent Office Library, with a view to improving the illumination, and showed a slide of a new form of reflector to be used in conjunction with a tubular lamp, for producing uniform illumination over an extended plane surface. MR. L. S. JAST, MR. J. DUFF BROWN, and MR. J. DARCH concluded the discussion, Mr. Jast reiterating his conviction that diffused general lighting ought to be the chief aim in library illumination.

On p. 154 will be found the paper on **Natural School Lighting** with which Dr. JAMES KERR opened the discussion at the last meeting of the Society. He explains how, during the last few years, the importance of exact measurements of illumination has come to be recognized, and refers to the work of Cohn in Germany. He then describes some instruments he has used in examining the lighting of schools, and concludes by briefly summarizing the conditions which should always be observed in the design of school-

rooms, such as the position and area of the windows, and the colouring of the walls.

DR. N. BISHOP HARMAN, in the paper which follows (p. 157) deals with the **Artificial Lighting of School Rooms.** He bases his paper on a large amount of experimental work which he has performed for the most part in L.C.C. Schools. After describing the photometer with which the tests were carried out, he passes on to discuss the relative merits of the different methods of lighting. An important section of the paper deals with shades and globes, and the possibilities of improved illumination and protection from glare by the judicious selection of a correct type of reflector. In conclusion, he makes certain recommendations with regard to the arrangement of lights over desks, and looks forward to considerable reform in this direction.

A communication from DR. W. J. ETTLES (p. 166) deals with the importance of **School Lighting** from the point of view of the preservation of the eyesight of children. The report of the remainder of the discussion is postponed to the next number.

The article on the **Illumination of some London Libraries** is concluded on page 167. In this section will be found a description of the lighting at the Surveyors' Institution and the Royal Colonial Institute, and also some account of the gas installation at the Livesey Library. An illustrated reference is also made to the lighting of a New York Club Library. The article is accompanied by sketches showing the arrangements of the lights in the various cases, and data are given regarding the intensity of illumination on the tables and shelves, &c.

This is followed by **Some Notes on the Illumination of a Library** (p. 175) in which occurs a diagram showing the distribution of lighting, both by daylight and artificial light, in the library of a private house. The various conditions of lighting desirable for this purpose are discussed. In this particular case, as only a central outlet was available, it was found necessary to arrange for the central chandelier to provide illumination for both table and bookshelves, and Holophane pines were used with this intention: as a result the illumination was considerably increased and a saving in current was made.

In the correspondence columns (p. 176) a letter appears in which the writer takes exception to some of the terms proposed by the Illuminating Engineering Society in the United States, and quotes Prof. L. Weber to support his argument. Special attention is devoted to the proposed term "specific intensity," and the desirability of distinguishing between "intrinsic brilliancy," as applied to luminous sources and expressed in candles per unit of area, and "surface-brightness," as applied to surfaces illuminated and expressed in foot-candles or lux.

The section devoted to **Short Notes on Illuminating Engineering** (p. 177) makes reference to the **Lighting of a Racquet Court,** noting the severe requirements as regards absence of glare. Another important requirement is that the light must be completely distributed so that the ball can never pass into a region of comparative shadow, where it would only be seen with difficulty. The development of artificial lighting of racquets courts, tennis courts, and other athletic purposes is regarded as an interesting illustration of the progress of illuminating engineering. Other notes deal with THE IMPORTANCE OF THE LAMP TRIMMER, THE PROTECTION OF THE CHAUFFEUR FROM GLARE, &c.

Some account of the last three lectures on Illumination, delivered by Mr. J. S. Dow at the Westminster Technical Institute, is given on page 180, and on page 182 will be found the usual **Trade Notes,** followed by the **Review of the Technical Press.**

Some Notes on Interior Lighting.

By Prof. H. Bohle, F.R.S. (S.Afr.), M.I.E.E. (South African College, Cape Town).

(Abstract of a Paper read at a meeting of the Institution of Electrical Engineers in S. Africa, 1910.)

The advent of the metallic filament lamp has profoundly altered the methods of electrically lighting interiors of buildings. For interior work the advantage of the high candle-power incandescent lamps, which are comparable with arc lamps as regards efficiency, but have the advantage of requiring no trimming and attention, is evident; their introduction has led to a considerable development of indirect lighting and of systems of illumination in which the reflection from light-tinted walls and ceilings is to a greater or less extent utilized.

AMOUNT OF LIGHT REQUIRED.

Direct Lighting.—In order to determine the quantity of light for different localities, I carried out a number of experiments in reading the ordinary type of text-book print in rooms of different colours. The values given in Table I. are actually the mean values of a number of observations by different observers.

TABLE I.

Illumination Required for Reading in Rooms of Different Colours.

Colour of room.	Illumination in Metre-Candles (British Candles).
Black	35
Deep Red	32
Dark Green	30
Pale Blue	28
Light Yellow	25
Cream Silvery ...	23
White	20
White (Indirect Light)	15

This table holds for distributed light, the maximum illumination of which is not more than 40 per cent greater than the mean. It should further be mentioned that the table has been plotted with regard to equal comfort in all cases. This implies, however, that the eye should roam as little as possible from the print in rooms of the darker colours, otherwise it becomes more tired with the higher illumination than with the lower one In the latter case, contrast is almost entirely avoided, and it is this to which the eye objects.

The divergency in the above table may be explained as follows :—

In the darker room, on looking at the print the aperture of the pupil becomes set to a certain width as long as one does not move the eye away from the book. At the same time one has the feeling of surrounding blackness, and the great contrasts prevailing make the eye roam instinctively. As soon as, however, the eye encounters the darkness, the pupil extends. In the next instant the eye strikes again the brilliantly illuminated paper and, consequently, the pupil contracts, and probably more than is necessary, because it experiences a glare. But too much contraction makes the illumination appear insufficient, and the eye has to expand again. This repeated expansion and contraction seems to make a higher illumination necessary.

The table tells us that the least light is required when the illumination is approximately uniform, an illumination obtained with inverted lamps. In reversing the lights of a lecture-room, so as to obtain indirect illumination by reflecting the light from the ceiling, the actual illumination was reduced from 23 (average) to 12 candle-metres. Yet the students were highly delighted with the new arrangements, and preferred it to the former method. For drawing and writing purposes it was certainly preferable, because shadows were almost completely avoided, a thing which cannot be procured with direct lighting, no matter how well the lamps are distributed. Pronounced shadows are, however,

very irritating, especially if they fall in the wrong place. It will also be found that the values of the above table become insufficient if the light

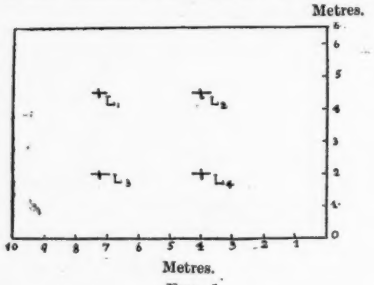


FIG. 1.

is badly distributed, an increase up to 10 or 12 per cent being necessary when the maximum value is double the mean value.

It seems probable that the eye is far more dependent upon contrasts than on actual values of the illumination. A lamp which will cause glare at night will often not do so during the day, although the light is there all the same, and if one walks from the sunshine into a brilliantly illuminated room, the latter appears nevertheless very dark.

Contrasts in artificial lighting are easily avoided if we paint the room white or with light yellow colours. Not only do we require less illumination in rooms with light colours, but less light will give a better illumination on account of the reflection of light from the walls and ceiling. The quantity of the reflected light depends largely upon (*a*) the colour of the surroundings,

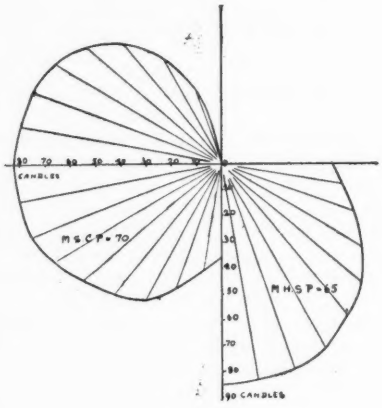


FIG. 2.

(*b*) the height of the illuminants above the plane in which the light is tested, and (*c*) somewhat on the size of the room. Numerous tests were made in a room measuring 10 metres by 6½ metres, having thus an area of 65 square metres. The lamps were arranged according to Fig. 1, in a manner that they could be easily placed at different heights. They were tested, first with conical metal shades, enamelled white, and then without shades.

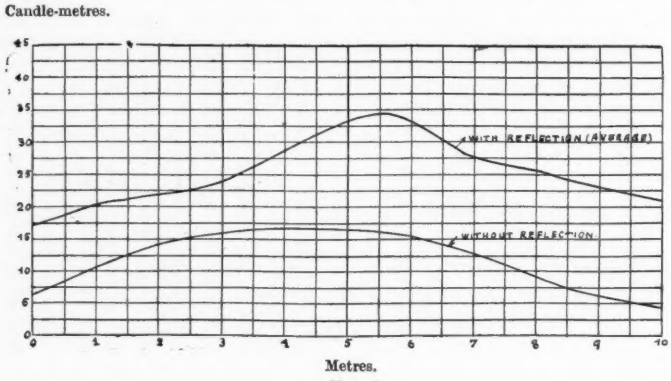
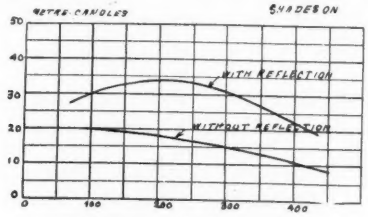


FIG. 3.

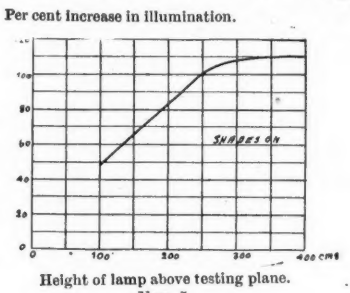
The room had a white ceiling and light yellow walls, but the paint was not new, although in fair condition. The lower portion—about 1·20 metres high



Height of lamp above testing plane.

FIG. 4.

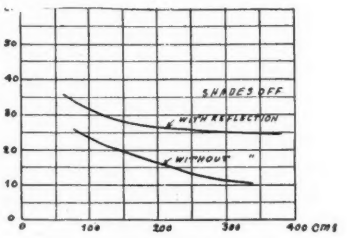
—was painted in dark green, but this had little influence on the reflection as the horizontal test plane was placed 1 metre above the floor. The average



Height of lamp above testing plane.

FIG. 5.

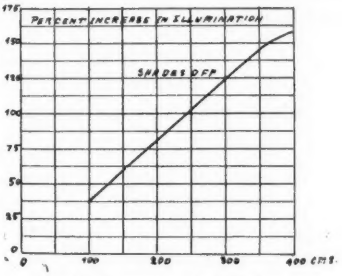
diffused reflection co-efficient of the room with all the furniture was approximately 0·5, as nearly as it could be determined.



Height of lamp above testing plane.

FIG. 6.

The light was tested—by means of an illumination photometer of fair accuracy—along the middle of the room and along the sides, and the average taken. Next the illumination was calculated from the polar curves of the lamps, taking into account the illumination due to all lamps in the



Height of lamp above testing plane.

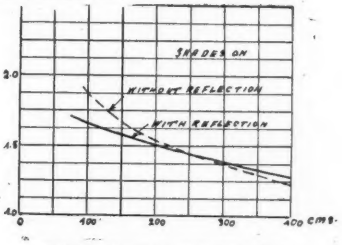
FIG. 7.

room (4). Siemens' one watt tungsten lamps were employed, with polar curves as shown in Fig. 2.

In Fig. 3 are represented two curves as calculated and as determined with the instrument. The average values were then obtained and plotted as function of the height of the lamps above the testing plane. The results are plotted in Fig. 4. From the latter follows Fig. 5, which clearly indicates that the amount of reflected light varies enormously with the position of the lamps.

The tests were then repeated, but this time the shades were taken off the lamps. The results are plotted in Fig. 6 from which follows Fig. 7.

Max illumination.
Mean illumination.

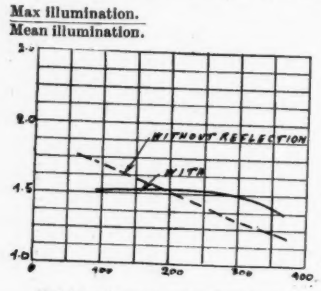


Height of lamp above testing plane.

FIG. 8.

We see that the amount of light due to reflection is considerably greater than before because the ceiling takes now a greater part in the reflection.

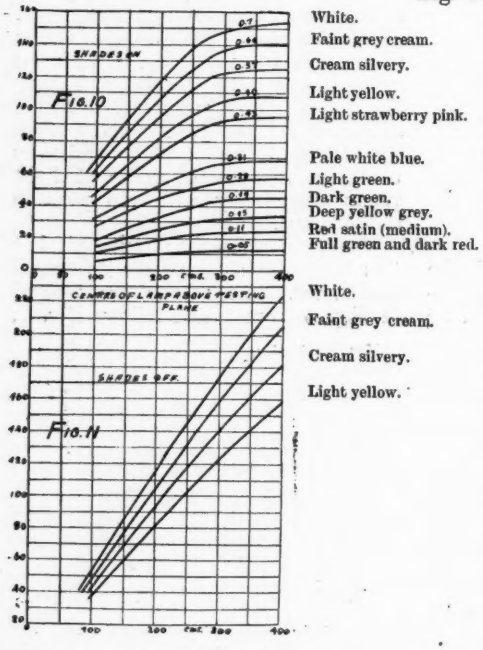
In Figs. 8 and 9 are plotted the ratios $\frac{\text{max. illumination}}{\text{mean illumination}}$ against the positions of the lamps. We see that by passing



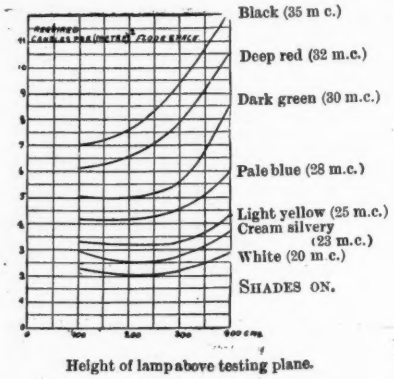
Height of lamp above testing plane.

FIG. 9.

from the dark room to the one with light yellow walls we increase the uniformity considerably.



With the aid of the results so far obtained we can now determine the percentage increase in the illumination for rooms of other colours as long as we know the coefficients of diffuse reflection for these colours. We then obtain Fig. 10, if we assume the same



Height of lamp above testing plane.

FIG. 12.

room as before and the same lamps. Fig. 10 with shades on, and Fig. 11 for lamps without shades.

Fig. 11 has been plotted for four colours only as one would hardly use lamps without shades in rooms with dark colours. The coefficients of diffuse reflection have been inserted in the figures.* In checking the results in two actual rooms with similar wall papers for which Bell determined the coefficients, a good agreement was found to exist. The furniture was, however, completely cleared out. (The value depends also slightly on the size of the room.)

With the results thus obtained we are now able to predetermine for any given room and colour the candle-power necessary, giving the results of table I. as average values. The candle-powers per square metre of surface (mean hemispherical) for lights with conical opaque shades have been plotted as function of the height of the lamps above the testing plane. The average value

* See Dr. Louis Bell, *Illuminating Engineer*, March, 1908. The figures hold for wall papers.

depends comparatively little on the distribution of the lamps, but the uniformity is greatly affected thereby. (The effect that with greater uniformity less light is required has been neglected in Fig. 12.)

Without shades, and taking into account the mean *spherical* candle-power of the lamp, we obtain Fig. 13.

The figures given in these curves hold, of course, strictly speaking only for a particular room, but experiments tell me that they can be employed with fair accuracy for any other room with distributed lights, as for rooms of average size the influence of the latter is not very great.

Example.—We are asked to fit up a room with an area of 100 square metres floor space with electric light so as to give an average illumination of 25 candle-metres. The walls are

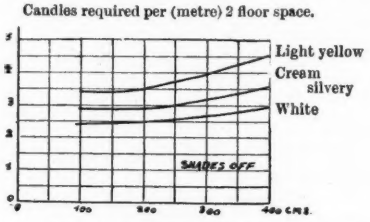


FIG. 13.

painted light yellow. From Fig. 12 follows that per square-metre surface we require 3·2 candles if the lamps are fixed 200 cms. above the testing plane or 3 metres above the floor. For any other illumination and height of lamps the light can now be easily determined.

Indirect Lighting.—In the tests the same room was used, and also the same lamps and shades, which were simply reversed. The illumination depended largely upon the distance of the lamp from the reflecting ceiling. The results are illustrated in Fig. 14. We obtain the best result when the distance of the centre of the lamp is 75 cms. from the ceiling. The different ordinates of the curve represent average values. 14 candle-metres gave results entirely satisfactory. Shadows almost disappeared and the result was highly pleasing. The lamps used were four tungsten 1 watt lamps of 65 mean hemispherical candle-power, so that with inverted lamps, fixed at the best distance from the ceiling—a distance depending on the type of shade and reflector employed—we require for a mean illumination of 15 candle-metres in a room with very light yellow walls and a white ceiling, approximately $4 \times \frac{15}{14} = 4{\cdot}3$ British candles per square metre floor space. For white walls this is approximately reduced to about 4 candles for the same illumination. If the reflection takes place not from ceilings, but from special reflectors in places where the ceiling is painted in a dark colour, and where the walls are also of a darkish tint, more light is required, not only because the quantity reflected is less, but at the same time more is required to ensure

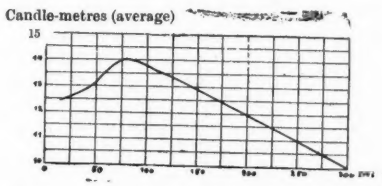


FIG. 14.

the same comfort. One would, however, hardly employ inverted lamps in rooms with walls painted in dark colours. The writer intends to carry out further experiments in connexion with inverted lighting. At present it may be mentioned that better results are obtained if the reflector below the lamp is perfectly opaque than with a shade which allows part of the light to pass through. The difference between two shades of identical shape, one opaque, the other semi-transparent, amounted to about 14 per cent.

In conclusion, I should like to point out again that the results given in this paper must be considered approximately correct only. In lighting it is impossible to lay down rules holding in all cases, and one must rely on experience. The experiments should, however, be of some use when the

planning of new buildings takes place. In the writer's opinion inverted light is used far too little, because it is considered too expensive. In reality it is little dearer than direct lighting if the latter is carried out properly. We certainly obtain less illumination than in the direct way, but the greater uniformity requires also a good deal less, and the more artificial conditions approach natural ones, the greater is the resulting comfort. With properly diffused artificial light, the eyesight of the human race would be materially improved.

The tests were carried out with conical opaque shades; the results, will, however, be little different with other shades, *i.e.*, as far as the average values are concerned, except as regards the uniformity. The conical shape gives results slightly better than the Holophane glass globe, which comes next in a set of six different shades tested.

Some Interesting Researches on Fluorescence and Phosphorescence.*

REFERENCE was recently made in this journal to the use of a phosphorescent substance as a light standard in a portable photometer.† It was then suggested that a more complete study of the phenomena of phosphorescence might help to solve some of the practical difficulties met with when it is attempted to use such substances as definite sources of light.

The light emitted from a luminescent body when it is undergoing excitation by exposure to a source of light is termed fluorescence; the "after-glow" is phosphorescence. These two phenomena are closely related and were studied together by Nichols and Merritt in the paper here referred to. They first established the relation between intensity of luminescence and time, which in the case of phosphorescence rapidly falls when the stimulation is removed, giving what may be termed the "curve of decay"; this "law of decay" is found to be always the same, although the time taken for the phosphorescence to become so feeble as to be invisible may vary from many hours to a very small fraction of a second.

It had been observed that variations in temperature produced considerable changes in the duration and the colour of phosphorescence, but no attempt had hitherto been made to determine exactly why this should be.

Examination of fluorescence and phosphorescence by means of the spectro-photometer showed the influence of temperature change.

The curves obtained showed that bands in the spectrum which, as seen with the spectroscope, appeared single really consisted of two or more overlapping components, this being indicated by a slight notch in an otherwise uniform curve. In some cases also change of temperature was accompanied by a shift of the bands of the fluorescence spectrum, sometimes towards the red and sometimes towards the violet. The intensity of different bands was by no means always similarly affected by temperature change, although in the main a diminution of temperature is accompanied by a decrease of intensity.

It is probable that the independent variations of brightness, duration, and position of overlapping bands account in some measure for the complexity of the changes which take place both in colour and duration of phosphorescence under varying temperatures.

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* E. L. Nichols and E. Merritt, *Phys. Review*, vol. xxxi., Nov., 1910, p. 500.

† *Illum. Eng.*, vol. iii., p. 596.

Photographic Photometry.

In a paper which recently appeared in *The Physical Review* Mr. Charles F. Brush described an application of photography to photometric measurement, based on the indication of small changes of light by the contrast of adjacent spots on a photographic plate. This is another illustration of the possibility of obtaining comparative results in photometry without the necessity of relying on the eye; a method involving the use of a thermopile, and due to Dr. Voege, has been previously described in this journal.*

Mr. Brush considers the method of photographic photometry to be simple and trustworthy, when certain sources of error herein described are eliminated. His apparatus consists of a glowlamp with frosted bulb, which projects a beam of light through an iris diaphragm on to a screen. This screen contains an elongated slot, normally covered by a drop-shutter which slides in vertical grooves. Behind the screen is a plate-holder which enables small portions of the plate to be exposed successively to the beam of light, the time of exposure being controlled by the drop-shutter.

In order to obtain the required comparison, the usual procedure is to expose uniformly alternate spots in a row first of all, and subsequently to use the intermediate spots for showing, by comparison with the first series, any changes in illumination which may have been produced. To get high sensitiveness in this method of photometry considerable skill is needed in the choice of suitable plates, exposure, development, &c., so that the greatest possible contrast may be produced by a given small change of light. The author, after extensive trials, has found a plate and a developer which give very satisfactory and constant results. The best times for exposure, development, and printing have also to be determined by trial. Under the best conditions Mr. Brush finds that "considerably less than one per cent change in illumination on the plate is clearly shown in the prints."

It is, however, of great importance that precautions should be taken to eliminate certain sources of error. For example, the temperature of the sensitive plate must be maintained as nearly constant as possible. The contrast due to 2° C. fall in the temperature of the room can be detected in a print, and in his experiments the author did not allow the temperature to change more than 0·1° C. (It will be recalled that the need for constant temperature was also experienced in the case of the "phosphorescent" photometer recently described.)

Two other sources of error are mentioned, arising from the behaviour of the plate as regards exposure and development. It was found that when the comparison and test spots were exposed to exactly the same light, the spots last exposed were always slightly less bright than those exposed first. That a small amount of light would be reflected on to neighbouring parts of the film during exposure of any spot was to be expected, but it was not anticipated that the effect would be different according as this weak illumination fell on the plate before or after the genuine exposure.

After many experiments, Mr. Brush concludes that this is due to the fact that a considerable amount of initial light energy is absorbed in *starting* photographic action which leaves no permanent record. Hence a strong light of (say) 100 units falling on a plate which is subsequently exposed to a weak illumination of (say) 2 units will produce a greater photographic action than 2 units followed after an interval by 100 units; in the latter case the slight initial exposure would not have any appreciable starting action, and this would all have to be supplied by the

* *Illum. Eng.*, vol. i., 1908, p. 239.

second exposure. It is very instructive to observe that a similar effect seems to exist in the case of the human eye, which has been found to require an appreciable stimulus before it begins to respond.

Another phenomenon of interest discovered by the author is the fact that photographic action continues *after exposure*, but is arrested as soon as the plate is developed. Several experiments were made in which the time that elapsed between exposure and development was carefully recorded, and it was found that the growth of action reaches its maximum in 15 to 20 minutes; subsequently, after an hour or two, a slow relapse takes place. Hence, the author concludes, if the interval between exposure and development is more than an hour, it is well to postpone the developing until the following day. It may be added that the gradual fading of a photographic image seems to be analogous to the disappearance of the "after-image" received by the eye. It is true that, to a casual observer, such effects seem to disappear very much more rapidly, but it has been shown that a really strong stimulus is experienced for much longer, and, indeed, in cases of very severe exposure, may even be permanent. On the other hand, Prof. G. J. Burch has found that, in a dark room, even ordinary after-images may take several hours to disappear. In the same way, although the disappearance of a photographic image usually appears to be gradual, this may be ascribed to the fact that exposure is always relatively intense. Possibly an under-exposed image vanishes more rapidly. It has even been stated that if a plate is kept sufficiently long the image will eventually disappear absolutely.

It is suggested by the author that the sources of error connected with photographic photometry may be easily guarded against. If this is so, it is possible that the method may prove of value as a means of detecting and estimating very small changes in illumination.

The Luminous Efficiency of the Fire-Fly.

THAT the luminous efficiency of the fire-fly is very much greater than that of any artificial illuminant has long been known, and reference has been made in this journal* to the work of H. E. Ives and W. W. Coblentz in obtaining actual figures for the percentage of visible radiation from these insects.

In a recent number of *The Electrical World*, Dr. Ives describes some further experiments which have been undertaken with a view to determining more definitely whether the visible radiation is the only radiation from the fire-fly, as has generally been assumed. In particular, attention was paid to the infra-red region, and a new method was adopted for estimating any possible radiation that there might be in this part of the spectrum. The method utilized depended on the action which infra-red rays have in extinguishing or reducing phosphorescence which has been previously excited in certain substances. The extinction may be recorded by taking a photograph of the phosphorescent surface, and in this way a record of the infra-red radiation can be obtained. Sidot blende was used as the phosphorescent substance in the particular experiments here described; it has the important advantage of being almost equally sensitive to reduction in the infra-red and the visible regions of the spectrum. This means that infra-red radiation of an order of magnitude similar to that of the visible radiation would be at once detected. It was found, however, that whilst an exposure of only twenty minutes was sufficient to produce strong reducing action from unobstructed fire-fly flashes, when a ruby glass screen was introduced, which was opaque to yellow-green light but transparent to infra-red, no effect was produced even with an exposure of three hours and a half. Thus it appears that there is no radiation between the visible region and 1·5μ, not at least of the same order of magnitude as the visible radiation.

* *Illum. Eng.*, Lond., vol. iii., Aug., 1910, p. 496.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Library Illumination.

(Proceedings at a meeting of the Illuminating Engineering Society, held in the House of the Royal Society of Arts (London), on Tuesday, January 31st, 1911.)

A MEETING of the Society was held on January 31st, the PRESIDENT, PROF. S. P. THOMPSON, D.Sc., F.R.S., being in the chair.

The minutes of the last meeting having been read and confirmed, the PRESIDENT called upon the Hon. Secretary to read the names of applicants for membership received since the last meeting, and also to read again the names of those presented at the previous meeting on January 16th, who would now formally be declared members of the Society.*

The PRESIDENT reminded those present that at the last meeting a discussion on Library Lighting had been opened, and they had heard the views of a large number of librarians on the subject. It was intended at this second meeting to give an opportunity to architects, lighting engineers, contractors, &c., of expressing their views on the points raised. Mr. W. S. C. Rae (Chief Librarian of Fulham Public Libraries) was then called upon to reopen the discussion, in which MR. HAYDN T. HARRISON, MR. J. H. QUINN (Chelsea Public Library), MR. T. E. RITCHIE, MR. V. H. MACKINNEY, MR. V. G. MIDDLETON, MR. W. W. TOPLEY, and MR. J. ECK took part.

Communications were read from MR. P. J. WALDRAM, MR. P. BLAGG, and MR. L. S. JAST, and MR. J. DARCH and MR. J. DUFF BROWN briefly replied to a few points raised in the discussion.

MR. R. J. WALLIS-JONES who, in the absence of the PRESIDENT, occupied the chair during the latter part of the meeting, announced that the next meeting would take place on Thursday, February 16th, when a discussion on School Lighting would be opened by DR. JAMES KERR (Medical Officer to the L.C.C.), and DR. N. BISHOP HARMAN.

NEW MEMBERS OF THE SOCIETY.

The names of the applicants for membership, read out at the previous meeting on January 16th, were formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on January 31st :—

Members.

Ambrose, Ernest	Assistant Engineer, Metropolitan Electric Supply Co., 11, Knight's Park, Kingston-on-Thames.
Chiswell, E.	Imperial Lamp Works, Brimsdown, Middlesex.
Lüdecke, Dr. G.	Works Manager, Imperial Lamp Works, Brimsdown, Middlesex.
Mather, A. A.	Electrical Engineer, 36, Farringdon Street, E.C.

* *Illum. Eng.*, Lond., Feb., 1911, p. 82.

Library Illumination.—Discussion.

[A discussion resumed at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London), on Tuesday, January 31st, 1911, at 8 P.M.]

MR. RAE (Fulham Public Libraries) said that from the illustrations that had been put upon the screen, the Fulham libraries came out rather well as compared with some of the other libraries in London, and he intended to call the attention of his committee to this fact. Mr. Darch had given an illustration to show what, in his opinion, would be ideal lighting for a newspaper rack, this representing what actually existed at present, he believed, at Cripplegate. This diagram, however, did not contain the figure of a reader at the stand. From the position of the lamp he thought the reader of average height would have done considerable damage to the lamp, and the rather fragile metal filament would be liable to be broken. This raised a point in connexion with the desire to obtain ideal lighting, viz., that none of the experts seemed to make any allowance whatever between the stacks of books for three, four, or more persons examining the books at the same time. He did not think that Mr. Jast's suggestion to light bookshelves from below, the light being switched on by the reader standing on a bar or rod, was a practical one, but he certainly thought that some system could be introduced whereby linolite could be made to throw light upon the individual bookshelves. This was a difficulty which, so far as he knew, librarians had not been able to overcome, and it was one which lighting experts ought to face as soon as possible. Mr. Hare, the architect of the Fulham library, and also of those at Islington, Hammersmith, and elsewhere, had given the question of lighting every consideration, and he was satisfied to a certain extent that the lighting at these places was very good. According to figures that had been compiled there were 2 ft.-candles at the bottom of the bookshelves at Islington, compared with only 0·4 ft. candles at Fulham, but to compare this properly, he thought that they should also consider the actual cost of the lighting. The gangways at Fulham had four 16 c.-p. lamps, but the gangways at Islington had seven clusters of three 16 c.-p. lamps in each gangway. Thus the cost at Islington of lighting each gangway must be considerably more than at Fulham, and he questioned whether the extra expense was justified for the improvement at the bottom of the shelves.

MR. HAYDN T. HARRISON said that he had never had an actual opportunity of carrying out the lighting of a library in his own way, but he had thought the matter carefully over, and it seemed to him that the subject must be divided into two parts, viz., the library itself and the tables at which people want to read and write. With reference to the library proper, he had very little to say except as regards the suggestion of placing lamps in a trench at the bottom of the bookshelves. This seemed to him rather a complicated way of doing it. Personally, he would deal with that by placing the lamps in the gangway in the ordinary way with suitable reflective shades which would bring the light down on to the edges of the books, and use a white drugget or carpet on the floor to reflect a share of the light on to the lower shelves. He thought this a less complicated way, and there could be no objection to the white drugget because it could be easily cleaned, and was in itself an advantage from the sanitary point of view. It should result in the lower halves of the shelves being nearly as well lighted as the upper portion. The question of reading books was to him a much more interesting subject, and he had had a

good deal to do with designing the best means of illumination for that purpose. Reading is one of the most trying occupations for the eye that we know of, and it was therefore essential that the literature to be read should be illuminated at above a certain degree of excellence. The figures given by Mr. Dow certainly showed that in many libraries the illumination was so low that reading would eventually result in the deterioration of the eye-sight and optic nerve. This, he thought, was brought about because the problem had been tackled by attempting to do the general lighting by the same means or light sources as the desk lighting. These two things must be dealt with absolutely separately. Those who were in the habit of reading and writing a good deal learned by actual experience that it was better to have a light source upon the table, none of the rays from which could get at the eye, and to use a small general light to see their way about the room. If he had the lighting of libraries to undertake he would certainly do it in this way. The lamps on the tables should be protected so that none of the light was allowed to pass through the shades. It might be argued that this would be too expensive, as it meant a separate light for every reader, but he pointed out that these lights need only be of low candle-power. It was well known that a 10 c.-p. lamp at a distance of 2 ft. from the book was worth a good deal more than a 50 c.-p. lamp at a distance of 12 ft. The result was that for ideal reading a small unit of light must be found. Our forefathers were in the habit of using candles properly shaded, and they did not suffer from eye troubles to the same extent that we do. In one case he had in hand, there were 8 c.-p. lamps in each of the standards; the supply was alternating current, and he had adopted 25 volts, in order to use a low candle-power lamp. The previous speaker had referred to the fact that metal filament lamps were fragile, but that was probably due to the fact that the lamps he was referring to were 200 volts or more, with very long and thin filaments. In his own case he was speaking of 25 volt lamps of low candle-power on portable standards, which were quite satisfactory, the filaments being much stronger. Therefore illuminating engineers dealing with a library must look for the particular class of lamp that would give the best result. As regards general lighting it was a great pity that the books themselves must be in the same room as the reader, because that meant that the general lighting had to do a great deal more than was otherwise necessary; but if the scheme were properly carried into effect, the general lights would be arranged to be shaded from the eyes of the reader. The valuable figures given by Mr. Dow would enable them to study the question of sufficient lighting for reading and writing. Some people said that 1 ft.-candle was sufficient, whereas in a great many instances it was a good deal higher. The room of the Royal Society of Arts, in which they were meeting, was an example. The standards on the table gave nearer 5 ft.-candles, but there was a possibility of the illumination derived being too high, especially when using a shiny paper, as in this case the source of light was very often reflected back into the eye, and caused a great deal of trouble. He hoped the Society would one day come to an agreement on these points, especially that concerning the right illumination for reading and writing.

Mr. J. H. Quinn said that at the Chelsea Library various forms of arc lamps had been tried for general lighting, then different makes of incandescent lamps, but of late years they had used, with a good deal of satisfaction, the spiral Nernst lamp, which was economical as far as current consumption was concerned, but was far from economical in the use of burners, which were expensive and short-lived. Since the whole of the lighting had been changed over to metal filament lamps it seemed that they had got to the end of their troubles, there being plenty of lighting at small cost for current and also for lamps. The figures might be of interest. In 1906 they paid £194 16*s.* 9*d.* for current, and this gradually came down until

in 1909 it was £157 12*s.* 6*d.*, and in the year just closed £135 15*s.* This of course was only half the story, as they had doubled the candle-power. In 1908 they paid £20 3*s.* for lamps, but in 1910 this figure was reduced to £4 18*s.* 8*d.* When they were dealing with limited funds, as most libraries were, owing to the smallness of the pennyrate, it was of immense importance to look after the cost of lighting. He had his own views as to the necessity for making the newspaper part of a library attractive by increased light. For some reason or other public libraries were still looked upon as philanthropic institutions and as counter-attractions to public-houses, and therefore committees liked to see the place nice and bright. For many years in the reference library there had been standards on the tables which the readers put on and off as they pleased, and he had found a great deal of care exercised in the direction of switching off the light when it was not wanted, or not switching it on at all if it were not absolutely necessary.

Mr. T. E. Ritchie expressed his surprise that more reference had not been made to inverted lighting. This form of lighting, in his opinion, had many advantages for the general illumination of a library, and particularly of that portion in which the books are housed. The question of furniture had been touched upon, and in this connexion inverted lighting gave an ideal amount of flexibility in the disposition of the furniture. It was often thought to be a very difficult matter to satisfactorily light gangways with inverted lighting, but he could show them that even under adverse conditions it was not so difficult as it might appear. He had one or two slides which he wished to show the meeting. The first one represented a portion of a room which was not a library, but was allied to one in many of its arrangements. It was used for the filing of documents, and contained a number of gangways which were 6 ft. long by 2 ft. 6 in. wide and 8 ft. high, in a room which was not more than 10 ft. 6 in. high. The room was lighted by two eight ampere inverted arc lamps, and the worst illumination given, on the floor in one of the corners, was 2·38 ft.-candles. The illumination of the shelves, and also that of the tables, was very carefully measured, and upon the latter it was found to be from 6 to 10 ft.-candles. It should also be mentioned that the general tone of the shelves was extremely dull, the prevailing colour being a rather dark green. The next slide showed the heights on the shelves at which the illumination was measured, and the next (see Fig. 1)

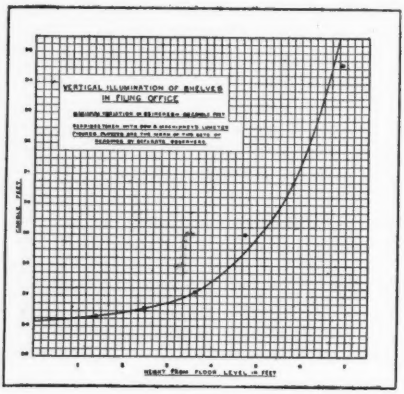

Fig. 1.

a curve of the readings obtained, from which it would be seen that on both sides of the shelves the lighting was so remarkably even, that it would, by the adoption of Mr. Harrison's suggestion of the use of a white drugget on the floor, probably have proved possible to secure almost uniform results. The measurements of the vertical illumination were made in the centre of the gangway and upon both sides. The first reading from the floor was taken at a height of 17 in., there being at that point 2·63 ft.-candles; at 30 in. there were 2·66; at 43½ in. the reading was 2·71; at 57 in. it was 2·9; at 71 in. it was 3·07; and at 83 in. it was 3·46 ft.-candles. In other words, the maximum variation in 83 in. was only 0·85 ft.-candles. He thought these figures demonstrated

very conclusively what could be done by a suitable use of inverted lighting, and that librarians ought not to ignore that aspect of the situation. He believed that if this system were more generally adopted, libraries, and especially those in which the readers had to make use of the book shelves, would be much more frequented by those who had any ideas of personal comfort and any consideration for their eyesight.

Mr. V. H. Mackinney remarked that there had been some reference to the lighting of the alcoves in the Patent Office Library. Since the last meeting he had been permitted, through the courtesy of the librarian, to make some experiments on behalf of Holophane, Ltd., in one of these alcoves, and the results had been interesting and instructive. According to the old scheme the illumination both on the shelves and table had been weak and unevenly distributed. Thus on the table the average value did not exceed 1·4 ft.-candles, while on the shelves in some parts it was as low as 0·3. In addition the exposure of naked metallic filament lamps had been considered trying to the eyes.

In the alterations tried it had been specified that no new wiring should be necessary, and that the present current consumption should not be exceeded; but notwithstanding these limitations, a considerable improvement had been made by using appropriate Holophane shades and slightly readjusting the positions of the lamps. The illumination on the table had been brought up to a *uniform* value of 4 ft.-candles, and the shelf-illumination was raised to 0·8–1·8 ft.-candles. Moreover, the distracting glare of unscreened filaments was now completely removed.

Referring to the arrangements in the Islington Reference Library, it might be pointed out that the type of shade used on the suspended lines of lamps was not efficient. He understood that the surroundings in this library were dark in texture and an unnecessarily large amount of light escaped upwards. He thought that if proper scientific glass shades, in conjunction with frosted-pip lamps were substituted, the illumination on the tables might be raised quite a third without increasing the current consumption, with the added advantage that any glare from the unscreened filaments would be avoided. In the same way he had calculated that it should be possible to secure a more uniform and higher illumination on the shelves in the Fulham library, without any increase in current consumption, by a few simple modifications in the position of the units and the use of appropriate shades.

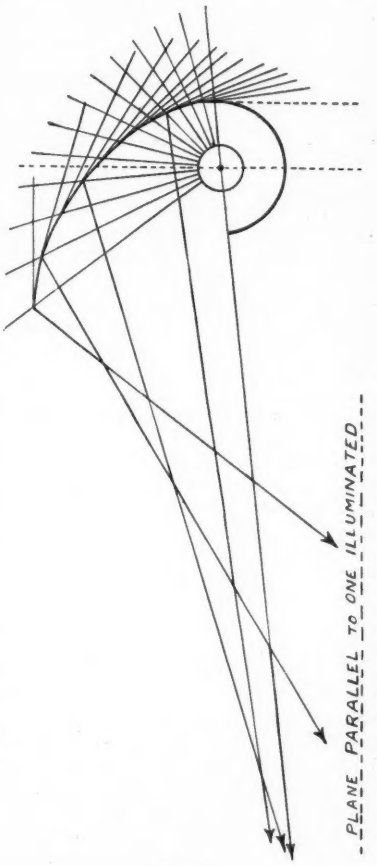

Fig. 2.
Reflector designed to give uniform illumination over a flat surface.

As regards the question of local and general illumination, it appeared that in the United States the method of entire indirect lighting, such as that employed in the theatre of the Institution of Electrical Engineers, was not now considered the best solution of the problem. A combination of local and general illumination was desired, and he would suggest a local illumination up to 10 ft.-candles (according to the nature of the reading) on the tables, and a general illumination of about one-tenth of a foot-candle. Reference had been made to the use of Holophane reflectors for table-illumination; in some cases the small amount of light allowed to pass through the glass was an advantage, as it served to provide a small general illumination. In one type designed for table use the possibility of this escaping light being troublesome to readers was removed by the use of a light satin finish.

Mr. Mackinney then proceeded to describe a form of reflector which he had designed in conjunction with Mr. Chalmers, and which was being worked out in the Holophane laboratory. The profile,* as shown in Fig. 2, is designed to produce perfectly uniform illumination over a flat extended surface, such as a shelf of books. The surface may consist of polished metal or silvered glass. The tubular source of light is screened off from the picture by a mirror semi-circular in section, which forms a line image of the source of light nearly coinciding with the original source. This reflected light diverges, therefore, in the opposite direction, and, together with the direct light from the source, is redirected by a second mirror of suitable contour on to the surface to be illuminated. The profile of this second mirror is designed so that the intensity of the light reflected in any direction is proportional to the distance of the surface illuminated in this direction, and to the cosine of the angle between this direction and the normal to the surface. This is secured by making the direction of the mirror change more rapidly when the light is reflected to the nearer parts of the surface illuminated, and less rapidly when it is reflected to the further parts.

The reflector has the advantage that it produces an *exceedingly uniform distribution of illumination*, and at the same time screens the eyes of the observer from the actual source. It may be noted that the semicircular portion of the mirror, facing the observer, may be removed, and diffusing opal glass substituted, so as to provide a certain amount of general illumination; this portion may also conveniently be used for an illuminated title describing the books on the shelf.

Besides its use for the illumination of shelves in libraries it is contemplated that the reflector will be found serviceable in any case, such as the lighting of pictures, placards and posters, &c., in which uniform illumination of a flat surface is required.

MR. V. G. MIDDLETON said he was thoroughly in agreement with Mr. Haydn Harrison's remarks as to the general arrangements for lighting in libraries. He had never had to light a public library, but he had had to deal with similar rooms, and his experience was that the indirect lighting referred to by Mr. Ritchie was not often possible—at any rate in the buildings he had had to deal with—owing to the absence of suitable surfaces to act as a reflecting medium, presumably due to decorative considerations. Mr. Ritchie's slides showed how well indirect lighting could be used in suitable circumstances, but these circumstances had invariably been absent from the buildings he had had to deal with. He would like to ask Mr. Ritchie how the cost of indirect lighting by means of arc lamps compared with metal filament lamps, because, as one of the librarians had pointed out, the cost of current entered very largely into the question, and it seemed to him that the use of

* The approximate form of the profile is given by

$$\text{Cos. } (2\phi + \theta) = A\theta + C,$$

where ϕ is the angle between the tangent and radius vector (from the source) at the point considered, θ is the polar co-ordinate of this radius vector, and A and C are constants depending on the position of the source and the size of the surface illuminated.

arc lamps for library lighting must entail a considerable addition to the cost of current. He commented upon the large number of libraries in which the lights were exposed to the eye, and the very unsatisfactory nature of such lighting, especially when the lamps were near the ground level. Great care should be taken to shield the lamps from the eye, and to make the general lighting subsidiary to the local lighting for reading on tables. With regard to lighting of tables, he thought the thing to aim at was to have the weakest possible light, and it should be possible to have lamps so fixed that the light could be varied according to the fancy of the reader. He had had experience with fittings of this class in bank work, and they seemed to give great satisfaction. Adjustable rise and fall standards were useful things to have in this connexion. With regard to the very interesting figures taken from lamps in position in completed libraries, as a contractor he realized the great difficulty in arriving at any definite figures beforehand of the exact amount of illumination required for, say, lighting tables or bookshelves, *i.e.*, before the buildings existed. His experience was that whatever might be the arrangement he was called upon to tender for, it was invariably altered later, and nobody seemed therefore to be able to work out beforehand the scientific distribution of light. Certainly the contractor could not be expected to do this when he did not know where the light had got to be thrown. Consequently it seemed to him that the poor contractors must look to the architects to be more certain in their requirements when they asked a contractor to tender, because otherwise they were putting upon him an impossible task; they were asking the contractor to work out something on scientific lines without giving him any real data upon which to found his calculations.

Mr. W. W. Topley (Croydon) said he was disappointed that the speakers who had referred to diffused lighting had mentioned it merely as a means for getting about the library, and that for the actual purposes of reading it was a thing to be avoided rather than otherwise. Personally, he entirely disagreed with the view. Unquestionably they should first of all make the greatest possible use of daylight in the lighting of libraries, with indirect methods of lighting artificially. Mr. Jast had mentioned experiments with indirect lighting in a magazine room of the Croydon Library. This room was some 45 ft. by 30 ft. and 14 ft. high. It was very dimly and unsatisfactorily lighted, and in the course of the rearrangements the walls were coloured a very light shade, and the ceiling white, and the sole source of artificial illumination was a number of lamps with reflectors placed close up to the ceiling, practically out of the range of the eye of any reader in the room. It was a satisfactory and fairly economical light, and the experience of those using the room was that it is a most desirable form of lighting. This sufficiently indicated to his mind that indirect lighting in itself was a desirable thing when it could be got, and he preferred to express the relative positions of the two forms of lighting by saying that, as far as possible, indirect lighting should be extended and point lighting reduced to the smallest possible limits.

Mr. Justus Eck (Union Electric Co.) on the question of indirect lighting said much had been said about the intensity of light, but it seemed to him that a good deal of attention should be paid to the quality of the surface one is reading from. Mr. Darch had particularly mentioned modern glazed printing surfaces, from which it was inevitable with direct lighting that some reflected light got into the eyes and spoiled either the contrast of the print or the beauty of the illustration, and it was in this connexion that the question of indirect lighting merited the greatest consideration. All those who had had to work intensely or closely at books, or read at night, or make calculations or drawings by means of indirect lighting, would agree with him that there was no other form of lighting with which they could continue to work without that fatigue which told that

it was time to go home or cease work. In an office he knew, it was very difficult for the people there, who were working with indirect lighting, to realize the time in the evening, so little did they feel the fatigue of their eyes.

MR. L. S. JAST (*communicated*).—As I am unfortunately prevented from attending the meeting of the Illuminating Engineering Society to-night, I venture to send a few observations which occurred to me in the course of the discussion at the last meeting of the Society.

In the paper which I had the honour to submit for your consideration, I presumed that there was little to be said in defence of local lighting, except that it was often a necessary evil. It appears from the remarks of Mr. Darch, and the account of the arrangements made in the Carnegie Libraries of New York, that both Mr. Brown and I are wrong. To quote Mr. Darch: "To rely upon general lighting alone....is a great mistake, being both a useless waste of light and a failure as far as reading utility is concerned"; and again, in speaking of the lighting of reading desks and tables: "No general lighting will meet the case, for it would involve a wasteful and intolerable blaze in order to obtain sufficient light to read by." I am, of course, quite incompetent to challenge the assertion made by Mr. Darch, though I am not prepared to accept it, but if it represents the expert view then I would make one observation. The only possible standard by which to measure the excellence of artificial lighting is day lighting; then it logically follows that as we depart from diffused lighting just in so far is our lighting bad; the extent, therefore, to which reliance is placed upon local lighting is the precise measure of our failure to solve the lighting problem.

Mr. Darch believes in a light for each reader, and that each reader should have control of the light. I regard the suggestion as undesirable for more than one reason, but it is, I think, sufficient to point out that to cater for individual idiosyncrasies in lighting is no more practicable than to cater for individual idiosyncrasies in other respects. People vary in height; why then should we not make all our tables and reading desks adjustable? People have the most contrary ideas as to heating; why should not each reader have an adjustable radiator in his immediate vicinity?

I come now to a point of fundamental importance, a point to which no reference whatever was made at the last meeting. What is the *physiological* need of the normal eye, in the matter of artificial illumination as regards reading? I draw particular attention to the word "physiological" here, because there is no reason to suppose that what the normal eye to-day demands in the matter of illumination has any particular relation to the amount of illumination which is best for it. It is a commonplace of experience that people now want a much brighter illumination for all purposes than they were perfectly satisfied with even a couple of decades ago. Still more is this the case if we go further back to the days of candles. Our sources of illumination have been growing steadily more and more brilliant, with the result that the eye is continually demanding a brighter and brighter illumination. Before, therefore, we are justified in laying down that such and such a foot candle-power is necessary for such and such purposes, it is essential that if any investigation has been directed towards the determination of the physiological requirements of the eye, the results of such investigation should be made known, and considered in relation thereto, and if no such, or if no adequate investigation has been made, then it is highly important that your Society should take steps to obtain these factors. Until that is done I submit that we are not even at the threshold of a truly scientific inquiry. I think that there is a suggestive illustration to be found in the present state of the food question. Prof: Chittenden's researches have shown that the hitherto accepted standard of the minimum amount of proteid required to keep the normal man in health is hopelessly wrong, and furthermore—and this is the point which is of in-

terest to us—that the greater part of so-called "hunger" is simply the habit response of the stomach to a consistent over-supply of food, so that hunger in most people bears hardly any relation to the physiological needs of the body in the matter of food. It is also, I believe, generally accepted now that every ounce of food taken in excess of the physiological need is almost certain to produce diseased conditions of some kind. What is true of one organ is, in all likelihood, true of another. So that one, I think, is justified in concluding that to supply to the eye all the light which it is thought it needs is not merely to give it more light than it really needs, but is to do the eye injury.

May I, in conclusion, and on behalf of all my professional colleagues, say how much we are indebted to the members of the Illuminating Engineering Society for initiating a discussion on a matter of so much general importance as the artificial lighting of libraries, and for the opportunity given to librarians to state their views, however crude these may be, to experts such as yourselves.

[Mr. Jast seems to have a somewhat excessive estimate of the amount of illumination which it is proposed to specify. We need hardly fear prescribing too much artificial light, *if wisely applied*, seeing that the intensity of daylight illumination on the reading tables of libraries often far exceeds artificial values. That it is difficult to read with a poor illumination of, say, 0·5 foot-candles is common knowledge, and Mr. Jast would be the first to condemn the lighting of a library in which such a value prevailed. We also think that for reading fine print Mr. Jast's personal experience would confirm the impression that one foot-candle is too weak. The only question is, therefore, how high our minimum should be set, and this query is answered to some extent by the fact that in the libraries examined and described in our last number a value in the neighbourhood of 2 to 3 foot-candles is about the average; in the few cases in which a smaller figure was recorded the conditions were clearly unsatisfactory and abnormal. These measurements, therefore, only confirm the practical experience of librarians, and help to show that the minimum illumination which it is proposed to specify is not unlike that actually obtained in the best lighted modern libraries.

With regard to Mr. Jast's inquiry for physiological data, a large number of researches on the connexion between intensity of illumination and visual acuity have been made; some of these show the effect of fading illumination on the power of detecting light and shade, others its effect on the ability to see fine detail. But in all cases a similar conclusion is reached. As soon as values lower than about one foot-candle are reached a marked reduction in acuteness of vision is seen, and it is also found that a less rapid but still well-marked improvement in vision occurs when the illumination is raised still further to, say, 3 to 5 foot-candles. As examples of such researches we may mention: Dr. L. Bell, 'The Physiological Basis of Vision,' *Illum. Eng.*, Lond., 1908, Vol. I. p. 329; Laporte and Broca, 'The Effect of the Chief Sources of Light on the Eye,' *Illum. Eng.*, Lond., 1908, Vol. I. p. 947; A. Broca, and also Massarelli, Second Congrès International des Maladies Professionnelles, *Illum. Eng.*, Lond., 1910, Vol. III. p. 601, &c. Cohn of Breslau, Koenig and Brodhun in Germany, Helmholtz, Uthoff, and many others have investigated the same problem in the past, and their results have been adopted and acted on by school authorities; see, for example, the remarks of Dr. James Kerr and Dr. N. Bishop Harman in this number.

There are also on record many other researches showing the changes in the retinal conditions of the eye, the presumed peculiarities of the rods and cones, &c., with falling illumination. These in the main bear out the contention that when an illumination of 3 to 5 foot-candles is reached a fairly "saturated" condition of the eye is reached; this enables it to perceive all ordinary detail with comfort. Yet for very fine work even more has been recommended.

We think, therefore, that Mr. Jast will concede that there is good reason for a tentative suggestion of specifying say, 3 to 4 foot-candles, so as to be on the safe side for ordinary reading purposes. Possibly progress in methods of illumination and new facts brought to light by the co-operation of the lighting engineer, the oculist, and the librarian, may lead us to modify the value somewhat in the future, but for the moment it is something to go upon.—ED.]

MR. JOHN DARCH (*communicated*).—In response to the kind invitation of

the chairman I have pleasure in forwarding a reply to the criticisms of my paper. Mr. Jast in his paper (p. 86) invites suggestions as to the desirability of doing away with "point" or local lighting in libraries, and of relying upon general lighting alone. An opinion on this point was given not only in my paper, but also by Mr. Harrison, Mr. Justus Eck, Mr. Dow, and Mr. Gaster to the effect that in general the best method of lighting a reading-room, both on physiological and economic grounds, was by a sufficient and properly screened local lighting combined with a moderate general illumination. This view, I may add, is fully illustrated by the data prepared by Mr. Dow.

The only argument adduced by Mr. Jast is a reference to daylight. I am

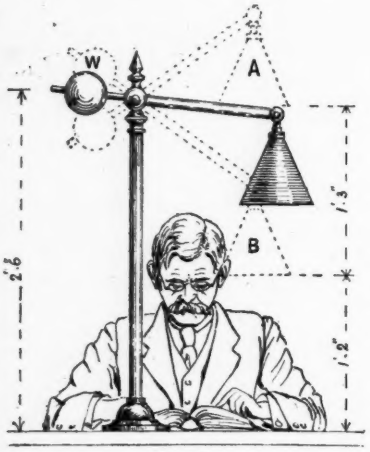

FIG. 3.

also a great believer in the principles involved in daylight illumination—the human eye is constructed for it (*Illuminating Engineer*, Vol. III. p. 608), but until we can produce something corresponding more closely with daylight in its abundance, distribution, and hygienic value we must be content to employ the light we have in the manner best calculated to meet the needs of the eye. These are (1) a sufficiency of light without excess; and (2) the opportunity of rest and relief therefrom by some such gentle contrast as nature herself affords in the grass-covered earth and the dark foliage; this, in a reading-room, can be obtained by a subdued, but sufficient general lighting.

With regard to the question of adjustable lamps, I should like to have heard more of Mr. Jast's reasons for objection to this method. What those reasons may be I fail to conceive: there is no extra risk, no extra cost, nothing to be lost, and much to be gained by an adjustable lamp.

Should damage to such a lamp be feared, and something of a "fool-proof" character be required, it may be found in Fig. 3, which consists of a standard upon which an arm swings vertically from A to B, with a balance weight W. A 16 c.-p. lamp would provide for a range of illumination of from 3 to 14 foot-candles. The shade can be of an unbreakable material and should be opaque.

In reply to Mr. Jast's second query one need hardly say that the upper

FIG. 4.

wall surfaces should be utilized to their utmost for diffusion; in fact, the white of the ceiling could be profitably extended down the walls in the form of a frieze. The lower walls should, however, be darker and, with the tables and floors, be free from reflecting surfaces.

The lighting of the bookshelves is, admittedly, a more difficult matter, for amongst the many suggestions there does not appear to be one which is free from serious objection. I would like, however, to say that the usual plain shade pendant, which appears to be fairly satisfactory for the upper part of the book-cases, can be much improved by doing away with the opal

shade and using a pair of opaque or nearly opaque cheeks on two sides only, as Fig. 4. This will enable the lamp to be lowered and thus give a more direct light on the books and greatly increase the visual acuity.

MR. DUFF BROWN said there seemed to be a great deal of general agreement upon this question of library lighting. With regard to local lighting, he thought a lamp on the table was a great nuisance. Some of the speakers had been rather severe on the architects, but it must not be overlooked that architects were not lighting experts. It seemed that the wiring system at present was to bring the wires to certain points in a room and to finish the room off with all the fittings added, thus making it impossible to alter them afterwards. He suggested that in all new buildings the wires should be brought only to the corners of the rooms, and thus give the lighting engineer a chance to experiment as to the best positions for the lights. In conclusion he suggested that a committee should be appointed, consisting of architects, librarians, and engineers, to fix a set of normal conditions for library lighting. No doubt certain conditions could be drawn up by a committee which would avoid, for instance, present methods of bringing wires into buildings, and the whole question could be placed upon a scientific and satisfactory basis.

MR. R. J. WALLIS-JONES, in proposing a vote of thanks to the readers of the papers and those who had joined in the discussion, mentioned that he had always taken the greatest interest in reflected lighting, and related an incident which occurred in the early days, when he was commissioned to go to a certain place near Liege and try to obtain information as to the exact way in which a particular mill was lit by means of reflected arc lighting. So important did they then consider this application of lighting that it was only after the greatest difficulty that he obtained the data as to size and shape of reflectors used, and the method of applying same.

MR. A. H. SEABROOK (*communicated*).—Good general lighting plus point lighting for reading desks and tables is, I think, the correct system to adopt. This point lighting should preferably consist of lamps and shades attached to flexible standards, so that the latter can be bent and twisted by the reader to suit his own needs. In this connexion I recommend frosted lamps and deep green shades. The proper lighting of book shelves, where there is only a narrow passage between each tier, is not at all an easy problem, but to save space tubular lamps with reflectors seems to be the best arrangement. My experience has been that the majority of architects are quite ready to adopt suggestions from the illuminating engineers as to the best arrangements of lighting in such buildings.

MR. P. BLAGG (*communicated*).—If reading-rooms were always *full* I see no reason why they should not be well and economically lighted by *general* lighting. Such lights must, of course, be high up and well diffused—if possible *indirect* lighting. For ordinary reading, where colour distinction is needless, perhaps a mercury-vapour lamp might be suitable. I must entirely dissent from Mr. Darch's suggestion of *arc-lamps* for general lighting: an arc is altogether too fluctuating to be admissible for use in a reading-room (at the British Museum they should be discarded even if only on the score of noise).

Unfortunately *general* lighting is too extravagant in current consumption to be advisable in practice, because it is necessary to keep practically *all* lights burning even when only two or three readers are in the room. Therefore *local* lighting is necessary in addition to some amount of general lighting.

I agree that local switching, under the control of the public, is desirable for local lights. I know of at least two free libraries where this is adopted—one at Ravenscourt Park, one at Fulham. It is true the public turn on more than they turn off, but the attendant is not overburdened with other duties and can look after that.

As soon as we get local lighting, however, we risk having bad lighting. There seem to be ninety-nine wrong positions

for every one right. In lighting *old* libraries there is no reason why the one right position should not be chosen. In *new* buildings it is not always easy to arrive at. I believe much of the bad lighting of reading-rooms is due to the difficulty a contractor has in getting information as to the future arrangements of furniture when he begins his work. He goes to the architect for information :—

"Oh," says the architect, "I have provided accommodation for half a dozen tables 12 ft. by 4 ft. and half a dozen newspaper stands of such a size. But I don't know where they will be fixed : the arrangement is no business of mine."

The contractor goes to the committee—or to any one member of it he can catch—and is told, "Nothing decided yet : it 's rather early days for that."

"But I *must* know," says the contractor.

"Oh, well, if you *must* know, I 'll bring it up at the next meeting and we will discuss it with the librarian and let you know."

If the contractor knows anything about committees he will be aware that by the time they "let him know" the walls will be plastered and the floor will be laid and he will have to cut half the building to pieces to lay his tubing. Therefore he makes a shot at it, probably following the lines of the ceiling design, which stand as good (or rather as bad) a chance of being suitable positions as any other.

If exact positions *can* be obtained table-standards and newspaper stand brackets make the soundest job. They are certainly open to the objection of fixing positions of furniture *rigidly*, and, if it is necessary to alter the spacing in order to put six tables in a row instead of five, a great deal of the floor has to be cut up to make the alteration. For this reason flexible pendants which bring the lamp to a similar position are sometimes preferable owing to their greater pliability : they are unsightly, but, from the illuminating point of view, satisfactory.

A drawing of the newspaper stands at Cripplegate was shown by Mr. Darch. I would like to add that the wiring to these is a *combination* of the *rigid* and the *flexible*. The mains are fixed rigidly round the walls at dado height. The brackets and their wiring are rigidly fixed on the stands. But the connexion between mains and stand is by flexible. As the gable end of each stand is pushed close up to the wall this flexible is shielded by it. The method is not perfect from an engineering point of view, but it allows the librarian to move his stands a foot or eighteen inches in either direction whilst maintaining the relative positions of lamp and paper.

Official Notice of Next Meeting.

The next meeting of the Illuminating Engineering Society will take place at the House of the Royal Society of Arts (John Street, Adelphi, London), on **Tuesday, March 14th, 1911,** at 8 P.M., when the discussion of the Papers on **School Lighting** by **Dr. James Kerr** (Medical Officer to the L.C.C.) and **Dr. N. Bishop Harman** will be resumed.

The Chair will be taken by **The President, Prof. S. P. Thompson, D.Sc., F.R.S.**

Applications for tickets should be made to the Hon. Secretary, MR. L. GASTER, 32, Victoria Street, London, S.W.

SCHOOL LIGHTING.

(Proceedings at a meeting of the Illuminating Engineering Society, held in the House of the Royal Society of Arts (London), on Thursday, February 16th, 1911).

A MEETING of the Society was held on February 16th, the PRESIDENT, PROF. S. P. THOMPSON, D.Sc., F.R.S., being in the chair.

The minutes of the last meeting were read by the HON. SECRETARY, and also the names of applicants for membership presented at the previous meeting on January 31st, who would now formally be declared members of the Society. (See p. 141.)

The President then called upon DR. JAMES KERR (Medical Officer to the London County Council) to open the discussion on School Lighting by reading his paper on the Natural Lighting of Schools. This paper was followed by one dealing with Artificial Lighting by DR. N. BISHOP HARMAN, which, in the unavoidable absence of the author through indisposition, was read in abstract by the Assistant Hon. Secretary. (These papers will be found *in extenso* on pages 154–166.)

A communication was also read from DR. W. J. ETTLES (see p. 166.)

The President then announced that, in response to the invitations that had been extended to them by the Society, several other bodies, including the Association of Medical Officers of Schools, the Association of Technical Institutions, and the London Teachers' Association had kindly sent representatives to the meeting, and there were also present officials of the London County Council from the Education and other departments. It was very gratifying to find this hearty co-operation on the part of those interested in school lighting.

Before these gentlemen were called upon, MR. J. S. DOW was asked by the President to put before the meeting the results of some measurements which had been made in various L.C.C. schools, showing the kind of illumination that prevails on the desks, blackboards, &c.

DR. R. S. CLAY (Principal of the Northern Polytechnic) spoke as a representative of the Association of Technical Institutions, and referred to the installation of inverted arc lighting at the Northern Polytechnic. He also suggested the use of a *distinctness* test for the rough measurement of illumination, and showed a device constructed for that purpose.

MR. C. A. BAKER (Electrical Engineer to the L.C.C.) said he had been responsible for the lighting of a number of Council Schools, and mentioned some of the difficulties that were encountered in obtaining satisfactory lighting, especially when the same room had to be used for different purposes.

MR. P. J. WALDRAM, F.S.I., spoke on the subject of daylight measurement and pointed out that owing to the enormous variation of daylight, the only satisfactory method was to make comparative measurements of illumination inside and outside a room.

MR. K. EDGCUMBE described a small photometer which his firm had brought out for measuring readily the illumination falling on a surface such as a desk or table.

MR. E. S. MORTIMER said that the London Teachers' Association, which he represented, welcomed the advent of the illuminating engineer in connection with school lighting, DR. H. R. HICKMAN referred to some trouble he had experienced in making photometric measurements, and MR. P. ABBOTT, speaking as a technical teacher, mentioned blackboard glare as one of the most serious troubles he had met with, and advocated special lighting for the blackboard.

A vote of thanks to the authors of the papers was then proposed and carried, and the President subsequently announced that the discussion would be resumed at the next meeting of the Society on March 14th.

School Lighting—Natural.

By James Kerr, M.A., M.D., D.P.H.

Medical Officer (Education) London County Council.

(Paper read at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Thursday, February 16th, 1911, at 8 P.M.)

When a doctor attempts to introduce a technical discussion before a company of experts he must be excused if he deals with it in a baldly practical manner, and not in the finer and more scientific way, which would be most interesting to the members of this Society.

I have to deal shortly with school lighting under natural conditions, Mr. Bishop Harman introducing the subject of artificial lighting.

It is in consideration of eye diseases that school lighting is of most importance to the doctor. The first man who worked extensively at school lighting was Dr. Hermann Cohn of Breslau, on whose tombstone may be read "Augenkrankheiten zu verhüten betrachtete er als seine Lebensaufgabe," and it is interesting to know that it was from his work that modern school hygiene has developed both in Germany and in this country.

Cohn's work was mainly occupied in investigation of the working conditions of the individual child, which indeed is the best way of examining the question.

His method of testing the lighting in the various parts of a school-room was by using the Weber photometer, which is too well known to need description here. He worked out the great variations with seasons of the year, and also distances from the windows. This still requires charting for the normal school-room.

For school purposes Wingen's photometer has been used in the London schools, and Mr. Harman will speak of it.

Cohn, however, recommended a simpler plan, which incidentally throws a side light on the German schools of forty years ago, in his suggestion to count the number of scholars in each room from whose place no part of the sky is visible. Then he developed the idea of the measurement of the solid angle of sky seen from each place by measurement with the stereogoniometer or Raumwinkelmesser, as he called it, devised by Weber for him.

He used a lens of 11·5 cm. focus to throw an image of the window on a paper divided up into squares of 2 mm. side. On counting up the number of squares in the area of the image of the sky, and multiplying by the sine of the angle of inclination of the lens he got a number which he called the reduced solid angle, and which was equivalent to the area of sky overhead which would equally illuminate the spot measured. This method is approximate and yet tedious, but quite within range of errors of experiment for practical school purposes. I have taken a hint from the pin-hole camera of Pleier, who photographs the window with a pin-hole, and places a gauge made by calculation over his photographic plate. Calculating out the solid angles, and reducing them, one gets a chart which, when photographed by a lense in a certain position, yields a gauge of reduced solid angles for any image thrown by the lens. Using a small camera obscura and spectacle lens a little apparatus is made for a shilling by which more rapid results can be permanently recorded on thin paper with the gauge than by more costly apparatus.

These methods, however, only measure direct skylight, and neglect reflected light, which, in a properly arranged school-room, is of great importance.

Another instrument has been used which is very neat and convenient, and which enables one to measure the relative distribution of light in a room, measuring the illumination from all sources in relation to the direct light from the sky. This is Thorner's light tester. The surface-brightness of a card on the spot A to be tested is viewed through a small hole B in a white diaphragm of the instrument. On this diaphragm by means of a small

mirror C and lens D an image of the bright sky is thrown. Stops $\frac{F}{5}$, $\frac{F}{6}$, or $\frac{F}{7}$ can be used to vary the brightness of the image. $\frac{F}{6}$ is generally used if the place is not bright enough for school work. The card A appears dark through the hole B, otherwise it appears brighter.

Probably by using an iris diaphragm, and carefully graduated scale, this instrument could be made to give relative values for the illumination at any point in a room.

A more elegant little instrument, which I only know from its description to this Society, is the "Holophane Lumeter," devised by Messrs. Dow and Mackinney. It appears to be portable, accurate, and capable of measuring the surface-brightness of any part of a room, so that it will be of value in determining the reflective power, for instance, of materials for walls or curtains, as well as for measurements of the lighting on school desks. This, of course, gives quantitative measurements, and does not compensate like the last instrument for varying sky brightness.

From the descriptions given it will be seen that measurements of various kinds are made by these different instruments, of which there are numerous varieties, and of which I have only quoted types :—

i. The measurement of solid angle of sky, which only gives direct illumination from the incident light, and except as regards minimum measurements is not of much value.

ii. The measurements by photometers (Weber's, Wingen's, Holophane Lumeter) give quantitative results, and which, for scientific investigation of lighting are a necessity. With light which varies enormously day by day, hour by hour, and inch by inch, it is doubtful how far exact measurements are wanted, at least by the ordinary school doctor, who has to pass an opinion on school lighting.

Very much depends on the eye itself. The eye and ear are about balanced as gateways of knowledge in school, perhaps the eye is the more important.

In the very young school child the mental effect seems largely proportional to the volume of retinal stimulus. The larger the image of a letter, for instance, the better it is recognized. There is a mental concentration required to recognize a letter which is quite well known, but which is also projected as a very small image on the retina. This means fatigue, which the young child always avoids as far as possible. Again, the undergrown or underdeveloped eye of the young child with its short axis means an excessive amount of effort of the ciliary muscle to accommodate the lens, and focus the image on the retina, especially for near things, and I think young children often give up the fatigue of accommodating to get a clear image, and by bringing their heads nearer the object get a large image, not so well focussed perhaps but giving a greater retinal stimulation. Poor illumination affects this retinal stimulus and leads to the eyes coming nearer the work, and this short eye to work distance is the earliest and worst school habit in its ultimate effects on the eyes, if these are in any way liable to damage. So that good lighting is particularly necessary in the infant departments.

Again, many years ago, being struck by the variable results of eye testing in a well-lighted room in one school on a hill, on tracing out the cause it was found that this was due to a reading lesson taken in a room exposed to the west, with the afternoon sun causing a certain amount of glare effect and fatigue on the eyes when they were tested in another room.

For this reason the test types which I had drawn in 1894 to be available at all distances from 10 to 20 feet, had a series of square dots added 1·4 millimetres side and 1·4 millimetres between each square. This is seen clearly by a normal eye as a row of square dots at 20 ft. if the light is sufficient for eye testing, but becomes fused into a line if the light is too poor for use.

On the other hand to test readily illumination in its effects on the eye, I mounted test type of the size known as J_1, on a glass slide, to keep it clean, and used it at a distance of half a

metre, as a test of sufficient illumination. This neglects the accommodation, and in a hypermetropic person or any one above 40 years of age it would be necessary that correcting glasses for this distance should be worn, if that is done then probably for all practical purposes the reading of diamond type at half a metre gives security that the standard of minimum illumination is attained.

The lighting of the school-room depends principally on the window area. For most of the work done in school it is advisable that the light should fall from the left. The windows on the left side of the room should be as large as possible from the point of view of lighting. They ought to be at least one-fifth of the floor area. Questions of ventilation and loss of heat in winter cooling and draughts make too large windows costly in heat.

Skylights, which are used in industrial buildings, might be used so far as lighting was concerned, but there are difficulties about heat in summer, and rain or melting snow in winter.

Window lighting facing the children ought not to be permitted, and conversely windows behind the children when the children sit in their own shadows ought now to be stopped. There are many rooms still existing, with this defect; and it is somewhat absurd to walk into a class-room of girls and find the girls sitting on the desks with their feet on the seats, doing their sewing, so as to catch the window light, which in the ordinary position at the desk they would lose.

The rapid diminution of light with distance from the window, which the photometer shows even in the length of one's own writing table, makes it inadvisable to have class-rooms wider than about 20 ft. Practical considerations of ventilation make 13 ft. about high enough with these dimensions.

A classroom for 36 to 40 children, which is about the standard size likely to be attained, would therefore be 20 or 22 ft. long, and would have about 120 square feet of window surface, beginning about 3 ft. 8 in. from the floor and extending to the roof.

Many rooms, however, are capable of great improvement by proper colouring. All class-rooms above 5 ft. from the floor should be coloured very lightly, almost white. Beams and rafters cause much loss of light, and as they are generally stained darkly, a coating of white paint should always be ordered.

Where there is insufficient window area all the aid possible is required from reflected light and the more distant parts of the room may require some help by the use of prism glass or of external reflectors. In using these aids care must be taken to avoid glare effects.

Glare arises when the brightness of illumination of an object whose image falls peripherally on the retina, is relatively great compared with the object whose image is centred on the yellow spot. Light incident almost horizontally on the eye from ribbed glass or prismatic glass, especially if there is sunlight falling on the glass is often very irritating in this way. The glass itself may be unsatisfactory. All kinds of obscured glass are objectionable, and so, too, unless it is absolutely necessary to ensure privacy for instance, patterned glass should be avoided. But windows often have their light transmitting capacity influenced in other ways. Not long ago I spoke of the windows of an infants' school as requiring the ground glass removing, and found that it was merely dirt.

Lastly, although hardly within our subject, there is the consideration of whiteness of paper and character of ink. The Gothic print, for instance, is a serious handicap of the German school child and some of the watered ink, and poorly printed stuff seen in schools even when badly lighted, is well worth the attention of school inspectors.

We may sum up then by saying that for the best effects of natural lighting in schools, properly planned schools with sufficient window area of clear glass, and well coloured walls to distribute the light are required, and further that attention should be paid to the pupils' position, and also to their attitudes; that their work should be such that clear images can be formed on the retina without excessive fatigue.

The Artificial Lighting of School Rooms.

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(Paper read at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Thursday, February 16th, 1911, at 8 P.M.)

The artificial lighting of school buildings has only recently forced itself upon the attention of school authorities and lighting experts. Until quite recently, within the life of the youngest here present, the use of artificial light in school hours was a rare incident, and one that afforded not a little interest to the pupils. The occasional fog was a joke, and the lighting of the gas a thing we coveted to take a hand in, whilst the ruddy glow and the roar of the flame that spurted from the long black arm of the gaspipe made the dull old class-rooms seem jovial.

The old time, happy-go-lucky school is gone, efficiency in work and appliance, economy of time and expenditure is the order of the day. With the extraordinary improvement in school building that has marked the last thirty years, and particularly the ever extending uses of school buildings for evening classes, a demand for satisfactory artificial lighting has arisen; and the rapid advances in methods of illumination give ample opportunity for satisfying the demand. It remains for us to examine critically the necessities of the schools on the one hand and the best means of arranging our available illuminants on the other. And we must always bear in mind that at our elbow is a trio of keen critics of our efforts—the educationalist watching the light; the school keeper grumbling at the botheration of upkeep; and the ratepayer incessantly protesting at expenditure.

In the course of this paper, which is based on experimental work performed for the most part in London County Council Schools at the instance of Dr. James Kerr, I shall hope to succeed in showing you that the plan upon which any scheme of lighting must be laid out is really quite simple, and that it is the same for all kinds of illuminants, whether oil, gas, or electricity. Difficulties will arise only in so far as the actual structural conditions of rooms are irregular, or the illuminant at our disposal is lacking in flexibility.

Photometry.—One necessity of our work is a simple, accurate, and portable photometer; the methods of the laboratory, the comparison of shadows, or Bunsen's grease spot method, are not suitable for the examination of desk lighting. A photometer that has been in use in London schools for several years is that of Wingen. It consists of a metal box, 8 in. × 6·5 in. × 4 in., within which, near one end, is placed a benzine lamp, the wick of which can be raised or lowered at pleasure. Outside the box is a small shelf covered with a white card upon which falls the rays of light to be measured. Inside the box is a similar white card lighted by the benzine lamp. The two white cards are viewed simultaneously at the bottom of a tube glazed with red glass, whilst the wick of the benzine lamp is adjusted till the cards appear equally brilliantly lighted. The value of the illumination is read off by looking through a small slit in the side of the box; a mark on the glass covering this slit is taken as a "backsight," the top of the flame as a "foresight," and the figure on the scale fixed on the side of the box beyond the flame that is found to be in a line with the "back" and "fore" sights gives the value of the illumination in metre-candles. Before commencing to work with this photometer I took it to one of the

London County Council gas-testing stations, and by the courtesy of the expert in charge, and with his aid, tested the instrument against the standard pentane lamp. The instrument was found to be correct for the purpose required; and the calibration which extends from 10 to 50 metre-candles was further extended down to 1 metre-candle.

If I might venture a criticism on this useful instrument, I would suggest that the principal difficulty found in its use lies in determining *what is the top of the flame* from which the measurement has to be taken. The shape of the flame varies greatly according to the extent of wick exposed; there is no difficulty when the wick is low and the flame small, but the difficulty is great when the wick is high and a long smoky flame is produced. I should greatly like to see the instrument modified in the following direction: A constant height of flame should be used, the wick should be turned up until it gives a clear smooth topped flame which shall reach a given height to be measured by sighting against marks on the near and far side of the box. Then the variation in the illumination of the white card within the box should be produced by moving the flame nearer or further from the card by a rack or pinion, and the value of the illumination would then be easily read off on a scale fixed to the rack-work. I have tried this construction in a rough model and find it works very well.*

Minimum Desk Illumination.—The possibility of distinguishing one object from another by sight depends primarily on the illumination of the object and its surroundings. A finger mark on a sheet of white paper is easily recognizable in good daylight, but not easy of recognition by candle light. The same principle holds good for distinguishing print on paper. Secondarily, the power of distinguishing any given object depends upon the familiarity of the examiner with the object examined. A normal sighted person of middle age will distinguish characters on paper in a poor light with greater readiness than a small child, because the characters are more familiar to the adult. Conversely a child requires a better light to learn to read than does an adult to whom reading is second nature. A standard of illumination is no new idea. Sir Henry Halford is reported to have counselled a patient: "If you wish to preserve your eyes never read by candle light anything smaller than the ace of clubs." From a number of experiments the least possible illumination permissible on the school desk of a child has been found to be equal to 10 metre-candles. This may seem a large amount of light if ten wax candles tied in a chandelier and their effect in a room is considered, but it is not large when compared with ordinary daylight in a fairly lighted room. In my consulting room in Harley Street, on a day when the sky is dull and there is not a ray of sunlight, I find the value of the light on my desk, placed 14 ft. from the windows, to equal 160 m.c.; and even at a distance of 24 ft. the illumination was equal to 30 m.c. On this experience 10 m.c. seems a most modest demand for a minimal desk illumination on each school desk.

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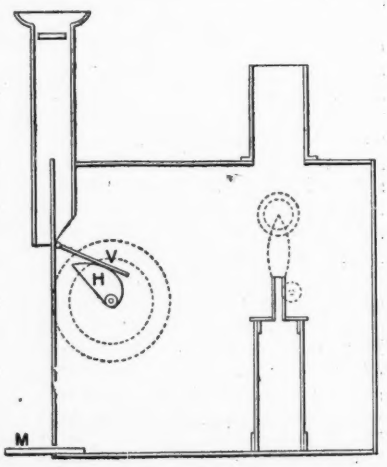
* The following illustration shows a modified form of Wingen photometer described by Mr. A. P. Trotter in the *Illum. Eng.* Vol. III., June, 1910, p. 367. In this form the benzine flame is fixed and the illumination on the inner screen is varied by means of a cam.



Oil Lighting.—Except for the use of country schools oil has vanished from the class-rooms. In what are known in political educational circles as "single school areas" oil would seem to have a long life before it. Lamps fitted with the central draught spreader burner are cheap to provide, simple in upkeep, and highly efficient. From a long and personal experience of these lamps in my college rooms at Cambridge, and in my private lecture-room at the same place, I am assured that these lamps will have few if any competitors in the absence of communal systems of lighting such as we enjoy in towns. I put this opinion forward in the full knowledge of the excellence of the modern petrol gas plant and the acetelyne-gas generator. In these we have most excellent systems of lighting country houses where there are attendants with reasonable leisure and skill, and an interested superman. But their application is more limited in the case of village schools; by reason of their cost of introduction and working, the necessity for skill and knowledge in working the plant, they will be beyond the pockets of the smaller communities and the ability of the village school caretaker. Moreover, village schools are better off than town schools in the matter of daylight, their buildings need not be overshadowed by houses, their fogs are fewer, their windows and walls keep cleaner, and lastly their curriculum should be arranged so that in day schools close work should cease with the failing of the natural light. There are certain points in which the use of oil lamps can be amended: first in the provision of better reflectors, secondly in the distribution of the lamps; both of these will be dealt with later on. Before considering the rival claims of other illuminants in the school world I should like to put in by way of parenthesis that I am not, so far as I know, in any way personally interested in any illuminating systems or companies, and that any opinion I may express for or against any particular mode of lighting is as unprejudiced as it is given to a man's judgment to be.

Gas.—Most of the London County Council schools are lighted by gas burned directly as an illuminant at the jets of fishtail or batswing burners, or used as a source of heat to render Welsbach mantles incandescent. The naked jet is fast vanishing, but it is of interest to give you the comparative experiments of illuminating effects of naked gas jets and of incandescent mantles performed in an actual class-room. A convenient infant class-room hung with four points of gas was fitted first with the most approved form of naked burner, Bray's No. 4, with No. 6 regulator slipped over it. The double burner gave a steady bright flame, there was no flaring. The desk illumination was then measured and

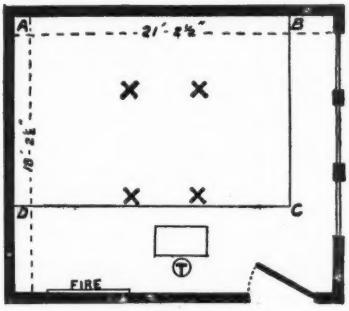


FIG. 1.

The plan of an infants' class-room showing existing lighting. A B C D, desk area. X X X X, points of light. T, Teacher.

charted. Then these burners were replaced by Welsbach "C" burners and mantles, with "Calypso" shades. Although the gas consumed with the Welsbach burners was no more, perhaps less, than that burned with the fishtail burners, the desk illumination was increased nearly three-fold over the whole room. The desk area measured 179 square feet. With naked jets the minimal illumination prevailed over 26 square feet only, and then only when no obstruction, such as bodies and hands of children, came between the lights and the desks. With the Welsbachs, in no part of the desk area did the illumination fall below 10 m.c., whilst in most parts of the room there was an ample margin for the interference which bodies and hands make

with the light. Then the incandescent light has the great advantages of purity of colour, absence of flicker, and reduction of smoke. This room in which the experiment was made is not cited as an illustration of good lighting; on the contrary, it is bad when lighted with naked gas jets since the light is insufficient, and bad with the Welsbach because the lights are badly placed.

Incandescent Gas Burners.—Granting the superiority of the incandescent mantle how can it best be employed in schools, in the upright or inverted form? The one sole advantage of the inverted burner is the absence of shadow below the light, and the correlated ease of securing good reflection, but I shall hope to show you

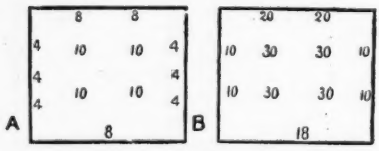


FIG. 2.

The metre-candle light distribution in foregoing room. A, with naked gas jets (Bray's No. 4 with No. 6 regulator). B, with incandescent gas mantle (Welsbach "C" Burner, Calypso shade). The contrast does not present the incandescent light in its most favourable arrangement. (See adjacent reflectors.)

that these desiderata can be quite easily obtained with the upright burner. Against the upright burner we have these counts: greater cost, more care in upkeep, greater sensitiveness to variations of pressure and vibration; and, what I deem the important point, more objectionable products in combustion. I scarcely think it is necessary to argue these points against the inverted burner; for I hope to be able to show that the one good point of this burner can also be secured with a proper usage of the upright burner. Putting the converse I shall hope to show that the one drawback of the incandescent upright burner, the shadow beneath the burner, can be easily overcome. I may note in passing that inverted burners have been used in schools within my observation, and did not prove satisfactory in the average school-keepers' hands.

On the particular kinds of upright burner little need be said, but I should like to put in a protest against the excessive liberality of the brass worker in loading the burner with metal; it adds to the cost of the burner (perhaps the maker does not always mind that!), and it is objectionable for another reason, we want the light as near the desk as necessary head room will permit; the waste brass work prevents this.

Shades and Reflectors.—These are most important parts of the equipment. Without a good reflector a Welsbach light is worse than a naked jet, because

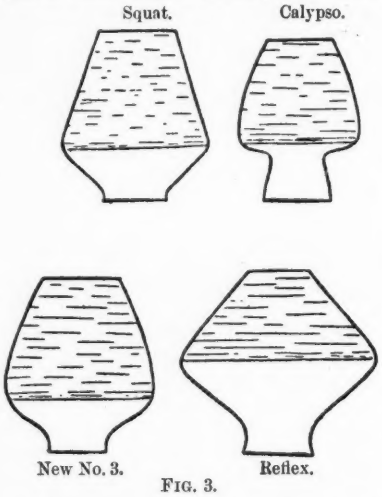


FIG. 3.

the brass work of the burner casts a black shadow beneath the light. By reflection from a shade the light can be so distributed as to be practically perfect. For school use the shade must needs be cheap and durable. It should not require the use of any chimney. It should reflect the light so that there is no shadow beneath the burner. It should also reflect the light so that the lamp at a given distance will efficiently cover a given area. Lastly, the shade should protect the teachers' eyes from the direct glare of an exposed mantle.

During my experiments four varieties of shade were found in use: "Squat," "Calypso," "New No. 3," and "Reflex." The inadequacy of the "Squat" as a reflector is obvious,

the sides subtend an angle of 30 to 35 degrees, and do not reflect light past the massive brass burner, consequently there is always a large dark blot immediately beneath the light. The "Calypso" has something of a parabolic shape, so that in its use the opaque mass of the burner is even more effective in stopping the direct downward rays. "New No. 3" differs only from "Calypso" in the shape of the lower clear glass portion, which is immaterial. The "Reflex" is an attempt in the right direction, for the opal reflecting sides of the globe subtend practically a right angle, *i.e.*, the proper angle for downward reflection. The effect of the proper reflecting angle of the "Reflex" is evident when a luminous mantle. The relative values of these shades in producing effective illumination was obtained by measuring the metre-candle illumination on the desks immediately below the burner and then at intervals of a yard along the horizontal desk tops, which were 5 ft. vertically below the burner. All the shades were examined in the same room and with the same burner and mantle and on the same evening. The tests were repeated on subsequent occasions. The improvement on the unreflected light by the use of any shade is great, but the results to be obtained by the use of what I will call the 90 degree shade globe is most striking (see table). The gain is obtained by turning down rays that would otherwise be dissipated upon the upper part of the walls of the room; further there is an invaluable gain, the teacher's and children's eyes are screened from the dazzling effect of the naked mantle. The general wall illumination of the room did not suffer, it was quite as good as when the "Squat" was used, and although not so bright as with the "Reflex," yet, owing to the absence of the dazzling effect of the exposed mantle, it appears better. The shadow beneath the burner can be estimated by the simple test of holding a large sheet of white paper below the burner. When no shade is used, a sheet of paper held a yard below the burner shows a deep shadow more than a yard in diameter; with the "Squat" or "New No. 3," deep circular shadows about 2 ft. diameter are cast. The

Table of results obtained with "Simplex" burner and "C" incandescent mantles, with and without shades. Figures are metre candles.

Shade.	Perpendicularly below burner.	1 yard.	2 yards.	3 yards.	4 yards.	5 yards.
None.	less than 1	2	2	+1	1	1
"Squat" "Calypso" "New No. 3"	6 to 7	8	5	2	1	1
"Reflex"	8	8	5	2	1	1
90 deg. shade-globe	22	15	7	2	1	1

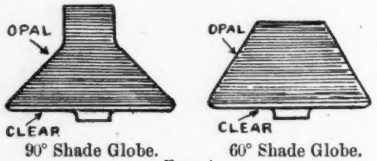
sheet of white paper is held beneath the burner, for there is only a small shadow cast by the burner. But the "Reflex" is bad for school-room use for two reasons: the upper half of the shade ($2\frac{3}{4}$ in. vertical) is of opal glass, the lower half ($2\frac{1}{2}$ in. vertical) is clear glass. So that nearly the whole length of the incandescent mantle is exposed to the eyes of every one in the room, and rays that project laterally from the sides of the mantle are not turned downwards, but lost on the walls of the room.

In the following experiments a comparison was made of the unscreened incandescent mantle, the various shades in use in the schools, and a shade, the opal sides of which subtended an angle of 90 degrees, and the lower margin of the opal reached the lowest level of the

"Calypso" throws a small central blot with a secondary outer ring of darkness. With the 90 degree shade globe, as devised, no shadow could be detected, even when the screen was held up to within a few inches of the burner. This 90 degree shade globe fulfils all the four conditions required for a school globe, and could be made without any difficulty or any material increase in cost as compared with those now in use.

Subsequent to these experiments I worked out the details of such a shade-globe, and it has been made by the Welsbach Co. and proved most satisfactory. It is no larger or heavier than ordinary shades, and costs scarcely any more.

During the last year or two a compromise (on the score of cheapness) on this shade has been largely used in



90° Shade Globe. 60° Shade Globe.

FIG. 4.

the schools. The sides of this new shade subtend an angle of 65 degrees, and the opal extends to the level of the flat plain glass bottom plate. The reflection is very nearly as effective as with the 90 degree shade-globe, and there is a complete absence of shadow cast by the burner.

Pendants.—Two kinds of pendants are now in use, a "two light" and a "harp shaped." The former is the ordinary ⊥ shaped pendant, with a light at the extremity of each arm. The "harp shaped" is a single light pendant, formed by a perpendicular length of tube suspending an elongated elliptical shaped loop. Since all rooms are not the same size, the two-armed pendant is not fitted for general use. With a properly devised "harp shape," the lights can be placed individually where most wanted. For such a pendant there is the usual ceiling plate, ball and socket joint, and a variable length of tubing to suit the height of the room. The loop should be triangular in shape—one side to carry the gas, the other side should be merely a support to balance the shade. The stop-cock on the gas side should be on the bend, and quite clear of the bottom tube. The burner should screw clear on to the bottom tube, without any wasted room filled in with needless brasswork. Attention to these small practical points will save several inches in the distance of the lights from the desks, and improve the effective illumination materially.

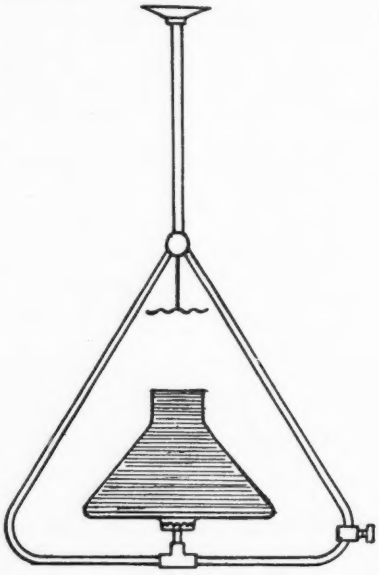


FIG. 5.

Arrangements of Lights.—In this matter one of our greatest reforms can be worked. Until now it would seem that the position of the pendants in the class-rooms has been set rather with a view to symmetry than to good lighting. There is often waste of light in some parts, and poor light in other parts of the rooms. It is difficult to lay down definite rules, as each class-room has to be considered by itself. But the following four points indicate the plan upon which points of light should be set out.

(i) Each class-room should be considered as being made up of two portions (a) the children's area; (b) the

teachers' area. The lighting of these parts must be arranged independently.

(ii) In the children's part left hand lighting must be arranged for as far as possible, exactly as in the rules for window lighting.

(iii) In calculating the area over which the rays of a lamp will extend, we must only take into our valuation those rays which proceed from lamps in front of the class to the back of the class. Lamps in front of a class illuminate to some degree the desks of the back row, but lamps to the back of the class do not help to illuminate the front rows of desks when the children are in their places.

(iv) There must be a clearance of 6 ft. 6 in. beneath pendants, and the luminous mantle must be as closely as possible approximated to this level, hence burners must be short, and cocks or bye-pass fittings must be placed on one side of the pendant arms, and not between burner and pendant.

From suggestions (ii) and (iii) it will follow that the main desk lighting will be arranged to come from the left and somewhat in front of the child. The gasfitter should mark the position of the first lamp to be hung over the centre of the first dual desk on the child's left of the front row. Proceeding, lamp positions should be marked out along this front row at from 6 ft. to 9 ft. intervals, according to the height of the desks from the floor; being closer in infants and further apart in the higher standards. The row of lamps thus marked out would give sufficient light for the front row and the second row of desks. A second row of lamps similarly spaced would light the third and fourth rows of desks. Since a lamp hung behind a child throws no light on the desk of that child, it follows that the space between the lamps from front to back of a room should be less than that between the lamps from side to side of the room.

In Fig. 6 the plan of a model room is given to accommodate 40 children. The children occupy two-thirds of the floor space and the lamps for this area may be hung so as to give efficient lighting in two ways, according as to whether infants or older scholars are to occupy the room. For infants the perpendicular distance from lamp to desk must be calculated as 5 ft. Three lamps will be required in the front row and three over the front row in positions marked A.A.A. For a room with well-grown children we need only reckon 4 ft. as the perpendicular distance from lamp to desk, and with this shortened distance the power of the lamps is improved by one-third, so that two lamps over the first and two over the third rows of desks in positions marked B.B. would be sufficient.

The illumination of the teachers' portion of the class-room must be taken

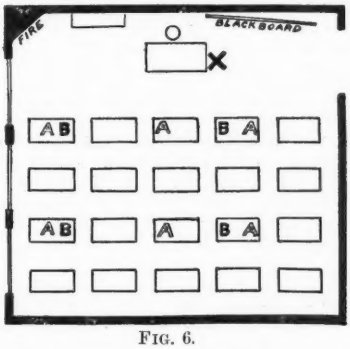


FIG. 6.

separately. Here are hung maps, charts, and the blackboard. Blackboards or slates should be fixed against the wall with the right hand slightly tilted forward, as shown in sketch. They should always occupy the right hand half of the wall behind the teacher. For illumination, when daylight fails, a pendant should be hung to the left of the teacher's desk in the portion marked X; this light should be fitted with a chimney and a metal shell-shaped reflector, opaque to light, to project the light well on to the blackboard or master's desk as required, and to present a dark back to the children.

Electric Lighting.—Handiness, simplicity, and ease of distributing points of light, complete absence of shadows below the lamp, the possibility of perfect reflection, healthiness in freedom from consumption of air and noiselessness, make lighting by the

electric glow lamp one of the most perfect means now available for school use.

The question of cost is not one I need discuss. We still require a carefully worked out comparison between the best form of gas illumination and the best form of metal filament electric illumination. There are such returns, but what I suggest is the desirability of such a return by a public authority based upon the working of two similarly situated schools over a long period. Further, as a corollary to these returns, we ought to have a return of the relative cost of upkeep in decorations in these two schools.

The recent rapid development of the metallic filament lamp has somewhat disordered our arrangements for electric lighting in homes and schools. Just before these lamps appeared in an effective form lighting companies and authorities in many districts had raised the voltages very considerably, *e.g.*, in one district of London the voltage was raised from 100 to 240 continuous current. No one remarked the change so long as carbon lamps were in use, but when the metallic lamp became desirable the evil of the high voltage was manifest. Lighting —except for certain special purposes, *e.g.*, lighthouses, public buildings, and shops—needs a uniform distribution of moderately powerful lights. With high voltages we get an uneven distribution of intensely powerful lights; the effect is bad in every way. The blackness of the shadows are intensified and the eyes are injuriously fatigued by the blaze of powerful lamps of high specific intensity. To permit educationalists to make the best use of the recent invaluable advances in electrical lighting electricians will need to arrange for low voltages in supply, say not exceeding 25 volts, or else evolve a lamp of no higher candle-power than the old 16 carbon which must be inexpensive and not unduly fragile. The reduction of voltages seems to me the more desirable aim, for with low voltages we can provide satisfactory reflectors of reasonable size and weight; whereas the large long lamps of present usage are particularly unsatisfactory to deal with. This is a matter of great importance, for efficient reflectors are required for metallic lamps not only to satisfactorily distribute the light, but also to reduce by contrast the high specific intensity of the glowing filament.

I should like to be able to get you to compare the lighting effects in two hospitals I work at: in one the voltage has been reduced to 25, and with metallic lamps the effect is perfect in flexibility and softness; in the other a 240 continuous current is irreducible, and the lighting is hard, fatiguing, and wasteful.

As regards the value of reflectors for glow-lamps the following experiments are of interest. A 16 c.-p. carbon filament lamp was used with 100 volts of the Strand supply. The lamp was hanging in a class-room chosen for its convenience, and the measurements made in a plane 4 ft. below the level of the lamp :—

Shade.	Below lamp.	1 yard.	2 yards.	3 yards.	4 yards.
None	5 m c.	+3	+1	1	1
110 deg., 3½ in. deep	20	9	5	3	1
80 deg., 5 in. deep	30	9	5	2	1

Two sorts of opal shades were in use in the schools; one subtended 110 degrees in the sides, and had a vertical depth of 3⅛ in. This shade did not cover the lamp, and the incandescent filament was exposed to the teacher's eyes. The other shade had sides subtending an angle of 80 degrees, and with a vertical depth of 5 in.; this shade completely screened the lamp from the teacher, and was the one to be preferred for class-room purposes, as the light below was also increased by one-third. Glow-lamps throw an image of the filaments. If a sheet of white paper be held under the lamp at the distance of a yard, four bright stars, each with a bright tail outwards, will be seen marking the corners of a square of one foot side. At the distance of two yards the separation of the points is two feet. The better the reflector over the lamp, the less noticeable are

these lines. Ground glass bulbs obscure the lines completely, but frosting the glass reduces the illumination by 25 to 30 per cent.

The distribution of the lamps should follow the lines indicated for the gas pendants. Beginning at the left hand of the children's portion of the classroom, a lamp should be hung over the centre of the first dual desk and from there across the breadth of the room at distances of not less than 6 ft., and not more than 9 ft. for 16 c.-p. lamps with 90 degree shades. With gas the fewest possible number of burners is desirable, for the more burners the worse the atmosphere; but with electricity, the points of light may with advantage be more generously disposed, and a cross room spacing of 6 ft. might be uniformly arranged. A second row of lamps should be hung in the same relation over the third row of desks. The lamps, as usually hung, err in being hung too far back; for instance, over a back row of desks, with the idea of their illuminating the desks in front, which they, however, fail to do when the children are present in their seats. The use of a front row of lamps with tilting shades, to light the blackboard in the teachers' section of the room, or desks in the children's portion, fails to serve both purposes in practice. It would be better to use a lamp to illuminate the desk and blackboard, and completely shaded from the children's portion of the room.

Refraction of Light.—There are on the market now a number of excellent devices in globes and shades which aim at the bending of the light rays by prismatic glass. Examples of these were experimented with, *e.g.*, prismatic bowls for gas and Holophane for electric light. The prismatic bowl is most satisfactory, particularly when a flat opal sheet rested upon the open mouth of the bowl. The Holophane productions are very satisfactory with electric light, and have been strongly recommended for school use by American writers.

Indirect Illumination by reflection has been highly recommended as affording the most perfect and natural mode of illumination. One reads of its adoption in some of the newer German schools. By this method powerful lights, usually arc-lamps, are hung from the ceiling with metal reflectors below them, the light is thrown up on to the white ceiling or to special reflectors, and reflected as a delightfully uniform and soft radiance over the whole room. The effect is not unlike daylight of modified brilliance, and it is largely and most successfully employed in shops and showrooms where deep shadows of direct light would be destructive of the general effect of mass and colour. I have also a very favourable impression of its use in museums. Of its use in work-rooms, where continuous and detailed work at the desk is required, my experience is unfavourable. The system was adopted in the New Anatomical Laboratories of Cambridge University some fifteen years ago, but it had to be superseded by the direct glow-lamp illumination.

In conclusion, it may be thought that no review of school lighting will be complete without a reference to the effect of certain rays upon sight. The harmful effects of ultra-violet rays have been made much of in quite recent months; already the literature of the subject is great. I should like to refer you to the work of Lieut.-Col. Pisani, I.M.S., presented to the London meeting of the British Medical Association in 1910. He dealt with the incidence and distribution of cataract in India, and with the possible causes that might account for the striking inequality of its distribution. The conclusion of his examination into the several possible causes was to wholly discount the influence of ultra-violet rays, for these rays are most abundant in the light of mountainous regions, and there cataract is least prevalent. It would appear from these and other researches that what we most need to trouble about is the provision of a sufficient and satisfactorily distributed light, and these ends are within our grasp.

[We have asked Mr. Harman to give some account of his 'Diaphragm Test' in the measurement of Eye and Brain fatigue. He has promised to demonstrate the instrument at the next meeting, if time permits.—HON. SEC.]

[We propose to publish the complete account of the remarks of speakers at this meeting, together with those at the adjourned discussion to take place on March 14th, in our next number. Meantime we add a communication from Dr. W. Ettles, which also deals with school lighting from the hygienic standpoint.—ED.]

DR. W. J. W. ETTLES (*communicated*).—The first school hygienist was an English oculist named James Ware, who in 1813 showed that short sight and excessive book work were related as effect and cause. The real awakening to the necessity of proper surroundings during childhood is due to Prof. Cohn of Breslau, as is mentioned by Dr. Kerr. Before alluding to the question of illumination, there are two main defects of vision regarding which I would venture a word.

We are constantly told that the refraction of the juvenile eye is hypermetropic. This idea seems to be based on the fact that the axis of the eye is shorter than in the normal adult eye. I have very often examined under atropine the refraction of healthy children and have found no hypermetropia in normal eyes. The facts of the case, as I understand them, are that the crystalline lens in infancy is much more spherical than it is in the developed eye. There is a constant ratio between increased lens curvature and shorter axial length which makes the eye normal, and I submit that the accepted view that all infant eyes are hypermetropic is only a general error.

Then we have the equally common statement that there is a progressive development from hypermetropia, *via* normal vision, to short sight. Here again I submit that observed facts clash with the theory. By far the greater number of developing myopias do so by the astigmatic route; and at no period of the child's history have we a condition of neutralization with temporarily perfect sight in those cases which become short sighted.

I have read Dr. Kerr's paper with great care and interest, and entirely coincide with his views on the questions of daylight illumination. There is, however, one amplification I would make, and that is on the influence of wrongly directed daylight on posture. If one looks at a class seated in a room with the light coming from behind, one cannot help being struck with the contorted efforts of the scholars to keep their body shadows off the book. It must have an evil effect on the growing spine to have that faulty attitude renewed day by day.

As to artificial illumination, I am very strongly in favour of shaded and inverted arcs. The ceilings and walls cannot be too white or bright, although they ought not to shine, because no artificial light can be brighter than full daylight.

The source of illumination should never be visible to the workers in class; what we must aim at is the provision of plenty of diffused light. It is not really essential that the inverted light should be an arc lamp, but to my mind that gives the most effective solution of the problem. The inverted arc should be placed to one side of the room, that is to say, to the left of the scholars, so that the shadows may be as nearly as possible similar to those obtaining under daylight conditions. Arising out of this question of illumination there is an important point. We may arrange ideal surroundings for the children while at school, but how are we to combat the bad surroundings at home. The best way would be to abolish home lessons altogether. Otherwise, if tasks are set, children read by firelight, by any light, and sometimes almost no light, and the harm done at home will negative the thoughtful care of those having charge of them at school, as well as bring into undeserved criticism the use of the precautions they have taken.

Some London Libraries and the Methods of Illumination Employed.

(*Concluded from p. 107.*)

FULHAM PUBLIC LIBRARY.—(*Continued*).

AN interesting and enterprising novelty in the lending library is the arrangement of illuminated titles denoting the contents of different classes of shelves. The shelf lighting is accomplished by lamps supported mid-way between the shelves. The lamps are clear bulbs, and the opal shades above them serve rather to throw the light down on the ground than to illuminate the shelves. The introduction of a shade which would both screen these lights from the eye and also throw the light in the desired direction might be of benefit here.

A word or two may be said about the lighting of the Juvenile department by pendants. The reading illumination is somewhat under 2 foot-candles, and might profitably be increased; the shelf-illumination is about 0·6 foot-candles, and that on the attendant's desk only 0·9.

FIG. 7.—Fulham Public Library (Lending Department).

The use of unscreened metallic filament lamps must again be noted, and the arrangement of the lamps with respect to the reading desks (doubtless temporary) might be adjusted somewhat; in one or two cases there is a tendency for a shadow of the head to be thrown on the book. It may be suggested that in juvenile libraries the

same precautions that are considered essential in school-lighting to prevent strain on the eyes should be observed. When young children are concerned, the illumination should be, if anything, more carefully planned than in the case of adults.

Surveyors' Institution.

The general scheme of lighting in this library will be understood from the plan in Fig. 8.

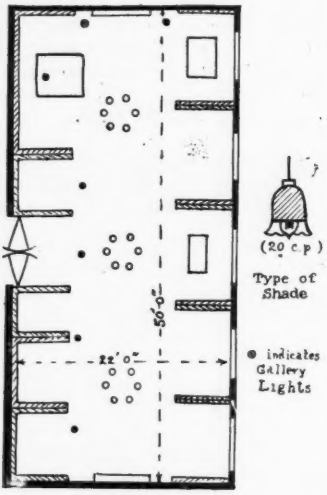


Fig. 8.
Plan of Library in Surveyor's Institution.

The sole method of lighting the floor is by the series of chandeliers shown. These appear to be unfortunately placed as regards both shelves and tables. As a result, although the watts per square foot are fairly high, the illumination on some of the tables was the lowest recorded during these visits, only 0·4 foot-candles. Some shelves, it is evident, lie in the shadow, and the natural weakness of the illumination seems intensified by the glaring effect of the imperfectly shaded filaments. The installation could doubtless be improved by adding appropriate shades to the central chandeliers. But it would probably be difficult to secure reasonably good illumination of either shelves or tables without the addition of new points specially placed for the purpose. The present chandeliers mainly illuminate the gangway. The illumination of the shelves in the gallery is higher, but, as in most cases in which imperfectly shaded lamps are placed near to the shelf, very uneven. The shades used could be improved upon. They allow the lamp to project and the naked filament to be seen, and their ground glass surface can have little serviceable reflecting power.

Royal Colonial Institute.

In the library of the Royal Colonial Institute the shelves go right up to the ceiling and there are tables at intervals for members to sit and write. The fact that it is only necessary to provide illumination for a small portion of the floor thus keeps the watts per square foot low, but the method of lighting is also efficient; chandeliers equipped with concentrating Holophane reflectors and 25-watt tungsten lamps are placed above the main tables. The illumination on most of the tables is high, ranging from about 5 to 8 foot-candles; the lamps are covered by the Holophane shades and the general effect is restful and without glare. There are also some brackets over seats equipped in a similar manner. There is no special shelf-illumination, the light reaching the shelves being derived partly from the rays escaping through the Holophane reflectors and partly from the white ceiling (the surface-brightness of which was 0·3 foot-candles). The illumination on the shelves (0·3 to 0·6) is low, but not lower than on the worst lighted shelves in many libraries which provide special shelf-lamps. As a matter of fact the illumination seems sufficient for the purpose in view, though possibly more might have been required in a lending library where crowds of people are scanning the shelves in a hurry. The ease in reading the titles of words was largely due to the fact that there was little possibility of glare being experienced by a person facing them, since no brilliant surfaces could be seen out of the tail of the eye; it was, however, remarked that shadows of the observer's head were cast on the books, a condition which was met with in many libraries where general

lighting by chandeliers is used. In a sense the method employed, chandeliers at intervals, constituted general illumination. But the effect of the shades used was to concentrate light on the tables, allowing only a relatively subdued illumination to the remainder of the room, and thus providing the conditions instinctively regarded as desirable in rooms in which serious reading is to be done.

On one of the attendant's tables the artificial illumination was low, only 0·8 foot-candles.

Patent Office Library.

The general nature of the lighting of this library has recently been described in this journal.* It consists of chandeliers at intervals along the gangways and special reading lamps on the tables. The illumination immediately under the reading lamps is very high, in some cases as much as 15 foot-candles, but it drops rather rapidly on either side of the standards It is suggested that this very high illumination is desirable in this library, as readers are constantly studying small type, patent literature, engineering drawings, &c. Again, the dark space between the lamps would be used by readers to stack their books, cases containing journals, &c., in any event.

Mr. Gaster, in the discussion at the meeting of the Illuminating Engineering Society,† has referred to the improvement in the lighting of these central tables; though the illumination has been increased ten times by the introduction of the table lamps, the expenditure of electrical energy has even been reduced, since half the side chandeliers can now be extinguished.

The illumination in the alcoves, by clear bulb imperfectly shaded metallic filament lamps, could probably be improved considerably by the judicious use of appropriate shades. The considerable distance of these lamps from the shelves in the alcoves leads to fair uniformity in illumination, and the value of the shelf-illumination, is up to 0·9 foot-candles in parts. But the fact that the eye is continually catching sight of the naked lamps is a drawback. The illumination on the tables, 2–2·5 foot-candles, is less than in the centre.* As in the Guildhall library, there is possibly a reason for this, namely, the encouragement to readers to use the central tables for continuous reading. The same plea might possibly be raised regarding the lighting of the gallery alcoves, where suspended clear bulb lamps are again used. The illumination, both on the tables and the shelves, is weak—little more than half a foot-candle. Yet it can hardly be expected that a person who has found a book in the gallery should take it downstairs to read; the usual practice among readers seems to be to read what they want *in situ*.

A few simple alterations might considerably improve the conditions of lighting, both in the galleries and alcoves; in the latter the illumination is in marked contrast with that on the attendant's desks, which is of the order of 8 foot-candles.

Livesey Library
(Old Kent Road, S.E.).

This interesting example of a gas-lighted library was visited by Mr. A. Cunnington, to whom we are indebted for the following data and results of measurements.

Reading Room.—This room, having an area of about 1160 square feet, is well lighted by six evenly spaced three-light fittings (with incandescent burners) hanging from the ceiling, about 12 ft. above the floor (see Fig. 9). The mantles are not shaded, but at this height are out of the range of ordinary vision; on the other hand, it may be suggested that an excessive amount of light is allowed to escape out sideways, and merely illuminate the walls. However, the general effect is cheerful,

* *Illum. Eng.*, Lond., vol. iii., March, 1910.

† *Illuminating Engineer*, London, Feb. 1911, p. 92.

* Some experiments in this section of the library have recently been made by Mr. V. H. Mackinney, and are described on p. 147.

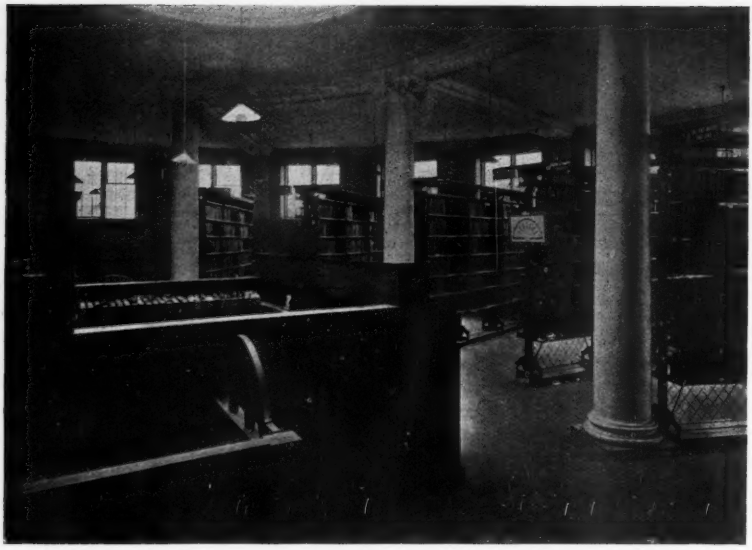


FIG. 11.—North Islington, Lending Library.

FIG. 12.—North Islington Reading Room.

and the illumination is remarkably uniform, that on the reading tables averaging 2·3 foot-candles, and that of the newspaper racks (which are for the most part fixed against the walls) about 2·7 foot-candles. One newsrack, however, fixed in a poorly lighted bay, showed an illumination of only 0·5 foot-candles. The walls of the room have been left of bare brick, having a brownish tint, and giving a surface brightness of 0·6 foot-candles.

Lending Department.—The gangways between the shelves are 3 ft. wide, and each row is about 18 ft. long, being lighted with two upright shaded "C" burners fixed in the centre of the gangway at 7 ft. from the floor (see Fig. 10). This, however, produces a very uneven illumination on the shelves, varying from 26 ft. candles near the top and immediately opposite a lamp, down to 0·4 ft. candles between the lights on a shelf 2½ ft. from the floor. The illumination on the indicator board averaged 2·5 foot-candles, and was fairly uniform.

The effect of the opal shades is to make the upper part of the walls in this room receive relatively little light, and the sharp contrast between the dark walls and the bright local lights gives a somewhat gloomy impression; it might be suggested that the illumination could have been made more uniform by whitening the upper walls, and selecting a type of shade which allowed them to receive more illumination. In this respect the lending department presents a sharp contrast with the reading-room, where, possibly, an excessive amount of light is allowed to strike the walls.

Reference Room.—General illumination is again adopted for this room which has an area of 630 square feet, and is lighted by two fittings, each containing three "C" upright burners fixed in large ornamental clear glass lanterns. The average illumination on the tables is 1·6 ft.-candles. The shelves being some distance from the source of light (11 ft. and 5 ft. respectively) are not so unevenly lighted as in the lending department. The values (which are high) vary from 1 to 6 ft.-candles, the usual figure being about 2 ft.-candles.

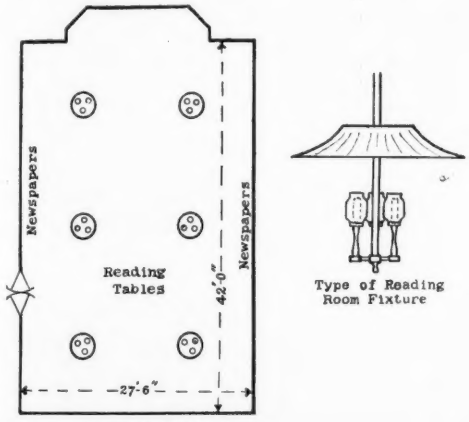


FIG. 9.—Plan of Reading Room.

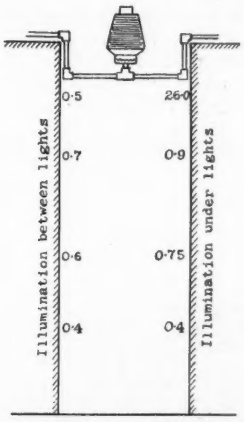


FIG. 10.—Diagram of Shelf Lighting.

Small Magazine Room.—This room was lighted by one central cluster of four Kern burners, without shade or globe. The average illumination on the tables was only 1·6, and owing to the light being somewhat low, and in the centre of the room, and the tables arranged round it, it was often difficult to avoid reading in one's own shadow.

ISLINGTON (NORTH) PUBLIC LIBRARY.

The remaining library (Islington North) calls for little comment. The system of illumination employed in the

lending and reading-rooms consists of simple drop-cords equipped with opal shades and 32 candle-power metallic filament lamps. The general scheme is shown in Figs. 11 and 12.

The illumination in the reading-room is about 2 foot-candles, and is fairly uniform ; the chief criticism that might be levelled would again be based on the glare of unscreened lamps.

In conclusion, it should be repeated that although this article has been mainly critical, and, indeed, could not otherwise have been of much service for the purpose in view, it should also be recognized that great progress has undoubtedly been made in library lighting during the last few years. Indeed, the conditions in many of the libraries are surprisingly good, though that is not to say they could not be improved. What is written here is merely suggestive. It would be useless to attempt to lay down definite rules at present, except on a few fundamental points, such as absence of glare, which can easily be complied with. There remains a wide field for discussion, and it is hoped that this article will suggest a few points on which closer agreement is desirable. J. S. D.

Illumination of a New York Club Library.

THE illustration accompanying furnishes one more example of a club library in which general illumination is secured. It will be seen that the room partly partakes of the nature of a lounge or writing-room, the shelves being at the side. The lightness of the surroundings is very serviceable in assisting the illumination secured by clusters of Holophane globes. To this extent it is general illumination that is aimed at, but local lights are also placed over the side chairs and sofas.

The effect is said to be very restful, all the sources being well shaded and placed out of the direct line of vision.

The daylight illumination, judging from the photograph, appears to be excellent, the effect of brightness and cheerfulness being probably due in a large degree to the fine reflecting surface of the ceiling.

FIG. 13.—Illumination of a New York Club Library.

Some Notes on the Illumination of a Library.

By An Engineering Correspondent.

Until one examines the matter by the aid of actual measurements one hardly realizes how profoundly the daylight illumination of an interior often differs from the artificial substitute. There seems a need for the collection of data contrasting the conditions in the two cases, and it occurred to the author that some data relating to the natural and artificial lighting of a small room used mainly for reading and writing purposes and dignified by the name of "library" might be of interest.

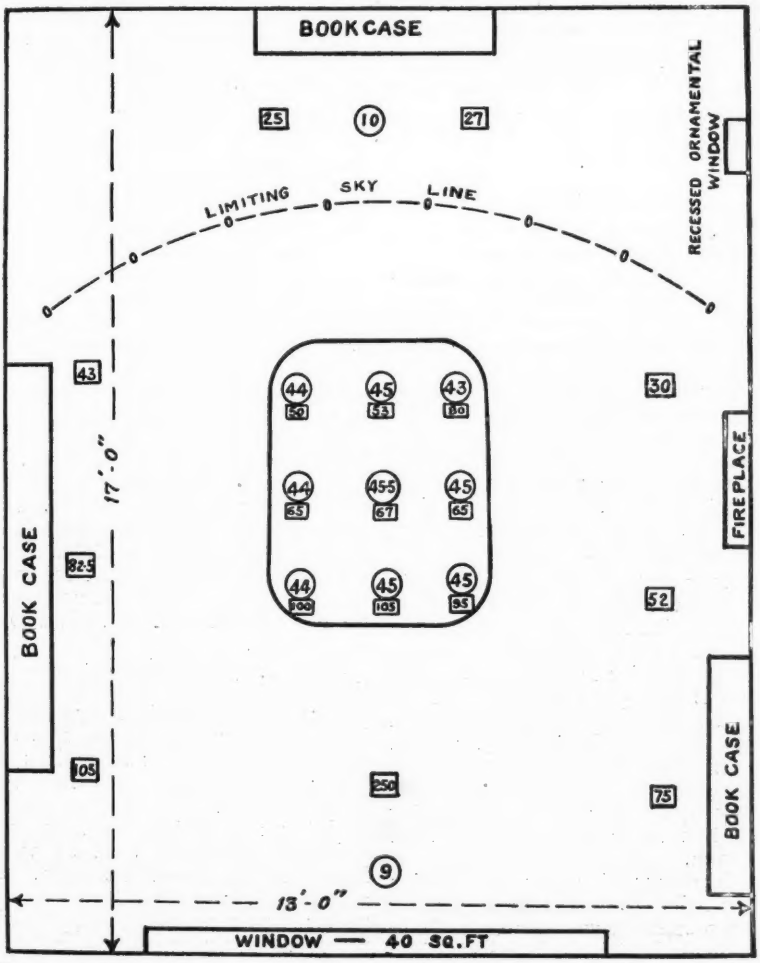


Fig. 1.—Showing Distribution of Daylight and Artificial Light in a small Library. The figures in circles indicate the illumination (in lux) in a horizontal plane at the height of the table: the figures in squares show the corresponding values of the daylight illumination.

A plan of the room in question is

shown in Fig. 1. It is 17 ft. long by 13 ft. wide, and is typical of the small studies to be met with in town residences. The main object of the lighting in such a case is clearly to illuminate the table in the centre of the room. But, in addition, there are three bookshelves lining the walls, which are constantly being used, and for which adequate vertical illumination, enabling the titles of books to be clearly distinguished, is very essential. It may be added that the wall paper of the room was of a very dark green colour, and therefore furnished little help to the general illumination.

The only outlet in the room consists of a central three-light hanging fixture. Originally this carried three 32 candle-power carbon filament lamps. The illumination on the table was considered sufficient, but it was noticeably difficult to read the titles of the books on the shelves. This, however, proved to be partly due to the unsatisfactory shades, which were of a heavily ground glass, red-tinted pattern. These shades gave little or no help in the way of concentrating the light downwards, and evidently absorbed a very large amount of the light emerging sideways which would otherwise have illuminated the bookcases.

It may first be pointed out that in this case the distribution of the daylight illumination differs considerably from that produced by artificial means, and the direction from which the light comes is also quite distinct. In the former case the source of light was a single window, about 40 ft. square. In the latter the light came from a single central fixture. Naturally, therefore, one would expect the lighting conditions to be quite distinct in the two cases.

Before suggesting any modification in the lighting of this room the writer made a series of measurements of the horizontal daylight and artificial illumination. The provision of window accommodation in this room (which faced north-west) seemed to be fairly satisfactory. The sky could be seen from every point in the room, and there were no houses opposite. The limiting sky-line, where the indication of the Thorner illumination tester* changed from favourable to the reverse, was situated quite far back in the room, as shown in the diagram. During the daytime it was almost invariably quite easy to see in all parts of the room in spite of the dark wall paper. Yet the actual values of the illumination varied very considerably in different portions of the interior, being much less uniform than the artificial lighting was found to be. In the figure the numbers in squares indicate the value of the daylight illumination in lux. It will be seen that the illumination at the window end of the table is double that at the other (though the eye seemed quite unconscious of the change). The illumination near the window is as high as 250 lux, that in the back of the room only 25 lux. They were obtained with a Martens photometer at 3.30 P.M. on a September afternoon, when there was a clouded sky.

Previous to the artificial lighting arrangements being modified the writer also examined the illumination on the table due to the incandescent electric lamps hung 3 ft. above the table. It proved to be practically the same, about 30 lux, all over the table. This would probably be considered ample for reading purposes, but, as stated above, the general illumination in the room was not sufficient, and did not enable the titles of books on the shelves to be clearly seen.

In readjusting the lighting conditions the writer was chiefly influenced by two facts: firstly, the desirability of throwing light in all directions, so as to illuminate the shelves as well as the table; and, secondly, the fact that he was limited to the central fixture, it being not desired to make any elaborate alterations such as would interrupt the use of the room. In addition, it was mentioned that a saving in power-consumption would be welcome. However, it appeared that a single central fixture ought to suffice for a room of this size if the light were properly distributed.

The supply voltage being 240, inconveniently high for the use of metallic

* For a description of this instrument see *The Illuminating Engineer*, Vol. I., June, 1908, p. 505.

filament lamps. It was eventually decided to wire two of the three central lights in series and to put an over-run carbon lamp in the other. Two 25 watt tungsten lamps were used and a 220 volt carbon 16 candle-power lamp substituted in the third holder (wired to a separate switch). The power consumed was then about 120 watts instead of about 180 as hitherto. Nevertheless the light was much improved. In place of the inefficient tinted glass shades Holophane pines were used. These were not of the concentrating variety, but served to throw the light in all directions and illuminate the shelves.

Now in a library one wishes to have comparatively subdued surroundings in order that the eye may not be distracted from the relatively bright book or paper. It might, therefore, be considered undesirable in a room of this description to have a very high general illumination. However, the fact that the walls were dark green, absorbing a considerable amount of light, gave the surroundings the desired subdued character in spite of the fact that the vertical illumination on the shelves and walls was fairly high, and one could now read the titles of the books in comfort.

The resulting artificial horizontal illumination is shown in the diagram by the figures in circles. When all the lights were switched on the illumination on the table was over 40 lux. Unlike the daylight illumination it was nearly uniform all over the table. (Eventually the cluster was hung somewhat higher, and an illumination nearer 30 lux was aimed at). It may be added that, owing to the diffusing effect of the Holophane pines, and the fact that they were hung fairly high up out of the normal range of view of a reader at the table, there was no impression of glare; previously, when the naked filaments could be seen projecting at the base of the red-coloured shades, there was a tendency for the lights to be troublesome to a roving eye.

It is interesting to observe how differently the artificial and daylight illumination are distributed; yet both would probably strike the average person working in the room as satisfactory. In conclusion, it may be added that quite possibly better results might have been secured by more elaborate arrangements, such as the provision of special local lighting for the table and shelves. The above account may, however, serve to show that substantial improvements can often be secured by comparatively simple methods.

Post-Graduate Course of Lectures on Illuminating Engineering at the Johns Hopkins University.

It will be recalled that we have several times had occasion to refer to the unique series of lectures on 'Illuminating Engineering' delivered at the Johns Hopkins University in October and November last, under the auspices of the University and the Illuminating Engineering Society (U.S.A.). The ground covered in these lectures was of a very wide nature, and the lecturers secured were recognized authorities in the particular subjects with which they dealt. It would have been unfortunate, therefore, if some permanent record of the work done had not been preserved, and we previously expressed our satisfaction that it had been decided to publish the lectures in book form.

We now notice that the lectures have been issued in two volumes, each of about 500 pages (in a subscription edition only), and can be obtained, if applied for before March 15th, from the Johns Hopkins University, Baltimore, Md., U.S.A. (price $4). They will doubtless form a valuable record of technical knowledge of different aspects of illuminating engineering.

CORRESPONDENCE.

"Specific Intensity," "Surface-Brightness," and "Intrinsic Brilliancy."

DEAR SIR,—I notice that in the list of symbols suggested by the sub-committee of the Illuminating Engineering Society in the United States,* the term "specific intensity" is proposed to denote what is generally described as "intrinsic brilliancy," *i.e.* candles per unit of radiating area. As the framers of this table invite suggestions it occurred to me that some modification of this nomenclature might be considered.

In the first place I should like to emphasize what Prof. L. Weber has previously pointed out,† namely that there are really two systems of units (termed by him "primary" and "secondary") which are used to describe the brightness of surfaces. The brightness of very brilliant surfaces, especially actual sources, illuminated lamp-shades, and the like, is expressed in candles per unit of area, and termed "intrinsic brilliancy." On the other hand, we have also to deal with moderately bright surfaces, such as the walls of a room, &c., which do not generate, but merely reflect light; in such cases we usually express the brightness in foot-candles, or other units of illumination, in the sense explained by Prof. L. Weber in the remarks quoted. There does not seem to be any very generally accepted term to denote this quantity, but I have used the term "surface-brightness" which is expressive and is a literal translation from the German (Flächenhelligkeit).

Now it seems to me desirable, in framing nomenclature of this kind, to discriminate between these two methods of denoting brilliancy, to retain the candle-power per square inch method exclusively for the very bright surfaces, such as incandescent mantles, filaments, &c., for which it is most convenient; we might also invariably use the term intrinsic brilliancy when this system is applied, and, further, we might even confine the use of the term to surfaces which actually generate light, or which, like shades, are illuminated by transmission and act as effective sources.

But in referring to illuminated surfaces, we might prefer to use the term "surface-brightness" to indicate that we are now dealing with reflected light, the understanding being that when this term is used, the same unit as that employed for intensity of illumination, *e.g.* foot-candles, lux, &c., would be employed.

Intensity of illumination would be convertible into surface-brightness by merely multiplying by the coefficient of reflection of the material illuminated. The relation between intrinsic brilliancy, f, and surface-brightness, f' ($\pi f = f'$) is also well known, but this appears to depend on the assumption that the surface illuminated follows the cosine law.

I might add that another word that calls for somewhat more precise international definition is the term "glare."

I am, &c.,

AN ENGINEERING CORRESPONDENT.

* *Illum. Eng.*, Lond., Feb. 1911, p. 74.

† *Illum. Eng.*, Lond., Feb. 1910, p. 116.

International Congress on the Applications of Electricity.

As we go to press, we have received a notice of the above Congress to be held in Turin this year, the opening ceremony extending from 9th to 11th of September. Particulars can be obtained from Prof. L. Lombardi, President of the Organizing Committee, 10, Via San Paolo, Milan.

Short Notes on Illuminating Engineering.

From all Sources.

The Importance of the Lamp Trimmer.

Mr. S. B. Stewart, writing in *The Gas Engineer's Magazine*, refers to the considerable saving in maintenance cost that can be effected by encouraging lamp trimmers to realize the importance of their work, and by adopting special methods to get the highest possible efficiency from these men. One company has established a system by which the trimmers are placed on a list in order of merit, *i.e.*, the man who cleans the greatest number of lamps at the lowest cost and has the fewest complaints is placed at the top of the list. If he holds this position for two consecutive months he gets a rise in wages, whilst the man who remains at the bottom of the list for a similar period is liable to be discharged.

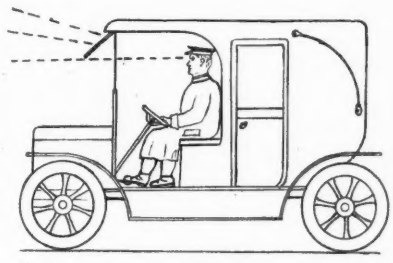
A thorough training is given to each trimmer before he is allowed to go out on a route, and every effort is made to interest the men in their work. The result has been a marked improvement in the maintenance, and a remarkable absence of complaints.

Prizes for Shop-Window Lighting

Prizes are being offered in Reading, we understand, for the best lighted shop windows. *The Acetylene Journal*, in commenting on this new departure, suggests that the idea should be developed, and that the example might be followed in America. It is recognized that a well-lighted shop window is one of the best possible mediums for effective advertisement.

Protecting the Chauffeur from Glare.

In the recent discussions on Street Lighting, reference has several times been made to the disadvantage of central lighting on account of the dazzling effect the lamps would have when seen in perspective by the drivers of vehicles. That this objection is worthy of consideration is clearly shown by the use on a large number of motor vehicles of the device indicated in the accompanying sketch. The small screen, inclined at about 45° to the horizontal, and attached to the canopy above the chauffeur's head, effectually shields his eyes from the glare of any lights placed above the field of vision with which he is concerned, and this probably increases considerably the power of judging distances accurately, and is a distinct aid to the driver when travelling by artificial light. The screen may be made adjustable as regards angle, so as to cut off as much or as little of the upper field of vision as is desired.



Automatic Prevention of Gas Leakage.

An invention for automatically stopping an escape of gas is mentioned in the *Revue des Eclairages*. The idea is that in the case of a bad fault in a lighting system, due to the fusion of a lead pipe during a fire, or even the cutting of a rubber tube, the sudden fall in pressure which would take place in the neighbourhood of the fault would operate a valve and cut off the section.

It is stated that the whole arrangement can be made very compact, and would apparently be used in much the same way as a fuse on an electrical circuit.

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Flashlights for Sportsmen.

According to a recent number of *Popular Electricity* some sportsmen, when hunting by night, find it convenient to have a small electric searchlight fixed to the barrel of their rifle, which is set in action at the instant they are aiming at the approaching prey. A lamp attachment worked from a dry battery is now made by a firm in Germany for use on the barrel of a rifle, either above or below the sights, the latter being in neither case interfered with. As the whole apparatus is quite small, it is suggested that it would be easy to carry an extra lamp and battery as a reserve when going on a long expedition.

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Light and Protection from Burglars.

We have referred before to the use of electric lights which can all be turned on together by a master switch as a protection against burglars. A suggestion which we notice in *Popular Electricity* is a step further in this direction, viz., to use "burglar alarm matting" at the door, so that when the burglar stands on the mat in attempting to pick the lock, he closes a switch which not only rings a bell, but floods the porch with light. This arrangement could of course be put out of action during the day.

Illumination of a Racquet Court.

We have on previous occasions referred to the use of artificial light for games played in the winter when daylight is available only for a very short period, or in the case of a game started in daylight, but so protracted as to make artificial light necessary at the close.

The illustrations on the opposite page show a squash racquets court lighted by four metal filament lamps with Holophane reflector bowls, hung 14 ft. above the floor, the upper view giving a good idea of the distribution of light over the floor.

The problem of lighting satisfactorily a building of this kind involves not only absence of glare, which would of course hamper the players, but it is also important to obtain a high degree of uniformity in the illumination in order that the ball, whilst in motion, should not pass from a bright light into shadow so as to cause an error in judging its position.

A very satisfactory uniformity was stated to have been obtained in this case, and it is stated that games can now be played in these courts by artificial light with the same ease as in the daytime.

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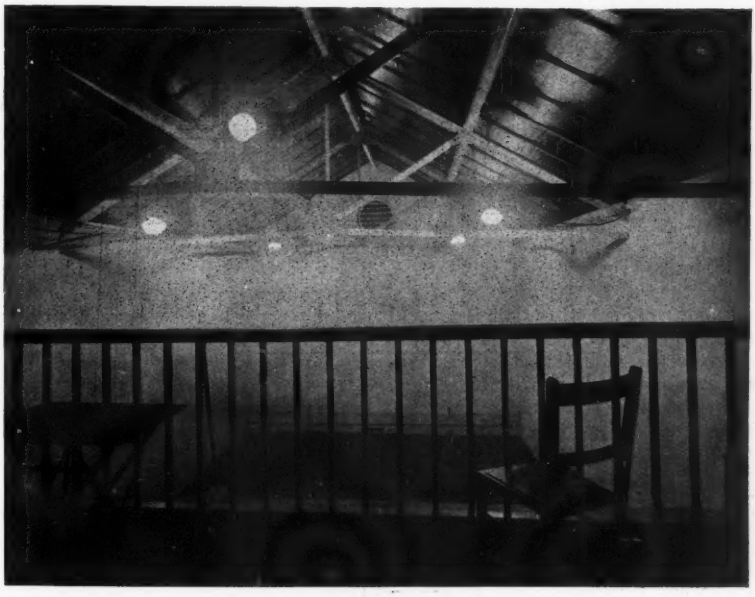
The Lighting of Buoys.

A recent number of the *Revue des Éclairages* contains a reference to a very large buoy which is to be placed in the estuary of the Gironde, and is to be lighted by oil gas.

The main float is a cylinder 10 ft. in diameter and about 21 ft. high, which carries a mast surmounted by a platform on which is fixed the lantern, of the usual dioptric pattern. A ladder gives access to this platform, and in the part of the mast immediately below there are two openings which enable the regulator and valves to be attended to. No details are forthcoming as to the consumption of this particular lamp, but the usual figure for incandescent lamps of this type is said to be about 10·5 candles per cubic foot (27 litres per carcel-hr.).

Interior of a Squash Racquets Court with Artificial Illumination.



View of Lighting from Gallery.

Lectures on Illumination.

THE three remaining lectures of the course of six, dealing with illumination, delivered by Mr. J. S. Dow at the Westminster Technical Institute, took place on Feb. 3rd, 10th, and 17th. That on Feb. 3rd dealt mainly with photometry, the lecturer tracing the development of the idea of light measurement, and pointing out how the progress in various artificial illuminants had brought home the need for more convenient and exact apparatus. A series of different types of photometers and devices used on photometric benches were described, and the degree of sensitiveness and accuracy possible in different circumstances was discussed. An account was given of some methods of obtaining polar curves and the use of the globe photometer.

The subsequent lecture on Feb. 10th was devoted to illumination photometers; a number of instruments were exhibited and described. The need for simplicity and convenience in such cases was pointed out, and the value of measurements of illumination as a means of preserving a record of lighting conditions was specially dwelt upon. The lecture concluded with a short discussion of daylight illumination and the development of street lighting, the units devised by Mr. Haydn T. Harrison and Dr. Clayton A. Sharp, and the work of Mr. A. J. Sweet being referred to.

The final lecture of the series was devoted to a discussion of different forms of interior lighting, some important points in the illumination of shops, factories, libraries, and schools being briefly commented on and illustrated by lantern slides. An interesting exhibit was the demonstration of the appearance of coloured objects under the light of various artificial illuminants, the various ribbons, &c., being arranged in a series of illuminated boxes borrowed from the Holophane laboratory. An experiment was also shown explaining the nature of ultra-violet light.

Railway Signals Lighted by Dissolved Acetylene.

FOR some time past dissolved acetylene has been used for lighting railway signals in America, and some particulars of the system in use are given in the *Revue des Éclairages* (Jan. 30, 1911).

Placed at the foot of each signal is a receiver, containing sufficient dissolved acetylene to supply two burners, of the size found most satisfactory for this work, for several weeks without recharging. The lighting and extinguishing of the lamps can be carried out in the usual way, but the consumption of the burners is so small that they are frequently allowed to burn continuously. The system has the great advantage, which applies also to its use for lighting buoys, lighthouses, &c., that each unit is self-contained, and does not depend for its supply on any system of piping or cables.

A further development of acetylene lighting for signals has recently been brought out by the Pintsch Company of Berlin, in which a flashing light is used. It is contended that the common practice of using flashing lights in lighthouses has shown that they compel attention, and are more readily perceived by sailors than a steady light. At any rate there is an undoubted economy by this plan, and the Pintsch apparatus is designed to produce a flashing light by allowing to pass at regular intervals just the amount of gas necessary to produce the flame momentarily. A bye-pass is provided to ensure that the flame is lighted at each passage of the gas, and the duration of the light can be adjusted to any required value. It is, however, found most satisfactory to work with the duration of the eclipse longer than that of the light.

The supply of gas is contained in a portable cylinder sufficiently small to be carried on a bracket on the signal post immediately below the lantern, thus avoiding a long pipe connexion from top to bottom of the post.

A Bowling Green Lighted by Acetylene.

THE accompanying illustration shows a bowling green at Highgate lighted by acetylene flare lamps, to the manufacturers of which, Messrs. C. C. Wakefield & Co., as well as to the courtesy of the editor of *Domestic Engineering*, we are indebted for permission to use the block. An important bowling match was in progress, and was finished at ten o'clock by means of these lamps. This is another example of the value of acetylene for temporary lighting, its use for night shifts on constructional work having been previously referred to in these pages.* We understand that in this case the players were quite satisfied with the brilliancy of the light.

FIG. 1.—Showing the use of a portable acetylene flare light to enable bowling to take place in the night time. The flare light is seen on the left.

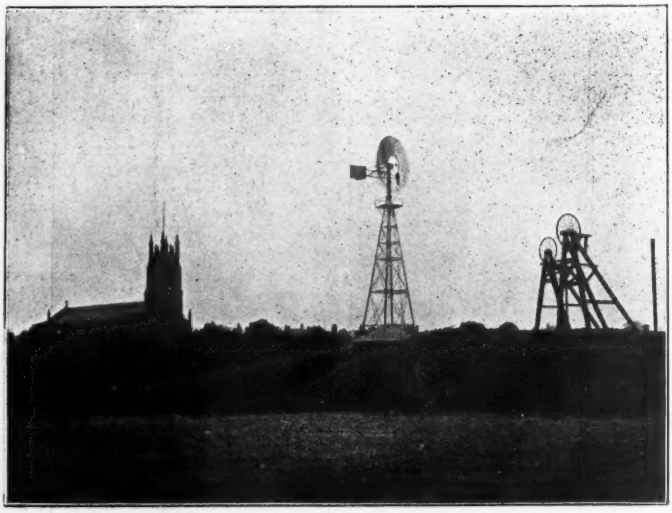
* *Illum. Eng.*, vol. iii., 1910, p. 448.

A Novel Means of Church Lighting.

By An Engineering Correspondent.

A rather novel method has been adopted for the lighting of Coseley Church; indeed, this church is unique in being the only one in the world lit by the means in question. Coseley Church is situated a few miles out from Birmingham, and has only recently been reopened after extensive redecorations and repairs. Electricity is now very widely employed for the illumination of churches and other similar institutions; but most people have been content to draw their supply from the local mains (if there should happen to be any).

The means adopted for the lighting of Coseley Church is one of Messrs. Childs' (of Willesden Green, London, N.W.) patent electric wind turbine plants. The turbine, which is 18 ft. in diameter, is placed upon a steel tower 60 ft. in height, and is erected about 200 yards away from the church upon the tailings of a disused coal mine. (See illustration.)



In the church there are twenty-seven 25 c.-p. lamps. There are also two in the side chapel, and two in the vestry. In the vicarage there are about thirty lights. In addition to the lighting, a motor is also driven for blowing the organ. The church lights and the organ motor are run upon a 50-volt circuit; a 25-volt circuit being used for the rectory lights. A 28-cell battery is at present employed, this being installed at the rectory. The whole arrangement is stated to work perfectly satisfactorily.

The power from the turbine is transmitted by vertical steel shafting to the generator, which is housed in the shed at the foot of the tower. The turbine wheel is fitted with Messrs. Childs's patent tail-governing gear, which renders it perfectly automatic in action, and ensures perfect trimming to the wind, so that there is no wastage in power—the maximum being extracted up to the normal capacity of the plant. When this point is reached the tail gear automatically takes the wheel out of the wind in exact ratio to the latter's increase in velocity.

The generator is of special Childs's variable speed type, with a range of speed of 4 to 1.

The first cost of the wind turbine installation is slightly in excess of a gas or oil engine plant; but, inasmuch as there are no running expenses, this small extra cost is soon more than overbalanced; in addition, the employment of a skilled mechanic is not entailed—what little attention is required can be given by an ordinary labourer, gardener, or odd man.

F. J. P.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Electric Lamps.

We had occasion to refer in our last number to the use of "Tantalum" lamps for station lighting, and published an illustration showing the lamps in use on a tube railway. We also mentioned that other stations would be shortly equipped in the same manner, and we are now informed by **Messrs. Siemens Bros. Dynamo Works, Ltd.** (Tyssen Street, Dalston, N.E.), that "Onewatt" high c.-p. lamps in conjunction with special Holophane fittings have been approved for use on all stations of the Great Northern and City Railway. The installation at one of these stations has already been completed, and the others are to be proceeded with immediately.

We are informed by **Messrs. Siemens Bros.**, that they are placing on the market yet another line of "ONEWATT" LAMPS, this time of 400 c.-p. in bulbs 12 in. long by 6 in. diameter. The filaments will be of drawn Tungsten wire, and the efficiency will be, as before, approximately 1 watt per c.-p.

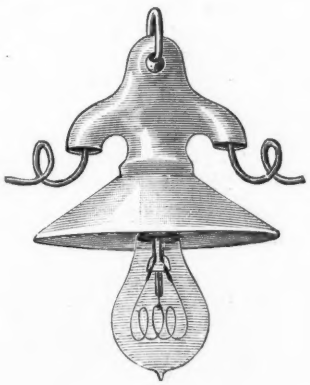
Messrs. G. M. Boddy & Co. (15, Gray's Inn Road, W.C.) inform us that their well-known "Metalik" lamps will in future be known as the "Philips" lamps. In view of the high reputation which these lamps have secured for long life, maintenance of candle-power, and low current consumption, it is of interest to know that they have been manufactured by the Philips Metallic Glow-Lamps Works, and will henceforth bear the name of this firm.

The London Commercial Electrical Stores (65 and 67, Knightrider Street, London, E.C.); price list of BRIMSDOWN METALLIC FILAMENT LAMPS.

The General Electric Co., Ltd. (67, Queen Victoria Street, E.C.); card showing two types of outside lanterns, designed for use with "Osram" lamps.

Porcelain Fittings.

The difficulty of preserving metal fittings and maintaining good insulation in an atmosphere either of chemical fumes or of extreme moisture may have led in the past to the abandonment of electric light in many works and other buildings where, had it not been for this objection, electricity would have been the most desirable illuminant.



To overcome the difficulty, ALL-PORCELAIN FITTINGS have been designed, and we illustrate here one of these lamp-holders, made by **The Edison & Swan United Electric Light Co.** (36–7, Queen Street, London, E.C.). The design, it will be seen, affords ample protection for the wires where they are led into the holder, and effectually prevents corrosion at the terminals. Other types designed to give even more complete protection to the lamp and holder are made by the same firm.

Messrs. Feld Bros. & Co., Ltd. (25, Budge Row, E.C.), send us lists dealing with INCANDESCENT AND ARC LAMPS; also particulars of SWITCHES and ACCESSORIES supplied by them.

Coronation Illumination Devices.

Lighting engineers are already active in preparation for the great opportunity afforded by the forthcoming coronation festivities. **Simplex Conduits, Ltd.** (Garrison Lane, Birmingham), have sent us a card describing and giving prices of their lighting strip and temporary holder for illuminations; also particulars of a coloured lantern for fitting over a lamp and holder.

Leaflets issued by **Messrs. Mather Bros.** (36, Farringdon Street, E.C.) give details and prices of a large number of gas and electric devices for illuminating purposes.

Forthcoming Chemical Exhibition.

We have received a notice of the CHEMICAL ENGINEERING AND INDUSTRIES EXHIBITION, which is to be held at the Royal Agricultural Hall in May next. Committees are at work in the important provincial towns, making arrangements for thoroughly representative exhibits, and judging from the preliminary list of exhibits which it is proposed to include the exhibition should be a novel and successful one.

Artistic Illumination.

The Banner Electric Co. (Youngstown, Ohio, U.S.A.) have sent us a booklet describing the remarkable effects of illumination which have been produced in the ALLEGHENY COUNTY SOLDIERS' MEMORIAL. The scheme of illumination has been planned by Mr. Basset Jones, Jun., and the Banner Co. have supplied the Mazda lamps. The coloured illustrations are a striking feature of the pamphlet, which is got up in elegant style.

Non-Encrusting Zincs.

The use of primary batteries in connexion with electric bells and railway signal work is considerable, and there should be a wide field for NON-ENCRUSTING ZINCS, particulars of which have been sent to us by **The Eyre Smelting Co., Ltd.** (Tonbridge, Kent). According to the tests described, which have been carried out by the National Physical Laboratory, and by various companies, the "Bamber" type of zinc should largely increase the efficiency and length of life of the primary battery. The zincs are made in a large number of different sizes and shapes.

Chanuka Candelabra.

The London Decorative Metal Works, Ltd. (44–6, Eagle Street, London, W.C.), have recently brought out a new CHANUKA CANDELABRA, the general lines of which are shown in the accompanying illustration. It is about 12 in. in height and of massive design, first class workmanship being exhibited in the carefully modelled ornamental details. It is manufactured with either a silver-plate or decorative bronze finish, and should be acceptable to those requiring an artistic table standard for candle lighting.

Mansfield Inverted Burner.

THE new inverted burner of **Messrs. Mansfield & Sons, Ltd.** (Derby Square, James Street, Liverpool), to which we referred briefly in our last issue, is a good example of what can be brought about by a large amount of experimental work and careful study of difficulties to be overcome. Messrs. Mansfield's solution of the problem of different qualities of gas in different localities is to manufacture nipples, nozzles, and injector tubes in complete sets of different sizes, all interchangeable and adaptable to the same outside case. Thus it is possible by selecting the correct burner parts to build up a complete burner, as shown in the accompanying illustration, that will

give the maximum efficiency obtainable with any particular quality of gas. As regards variation of pressure, the burner is originally adjusted for the lowest pressure likely to be met with, and will, by virtue of its construction, adjust itself to higher pressures. Messrs. Mansfield have found that when the hottest flame is being produced, the cone of the flame is double the diameter of the outlet, and from this fact it is possible to judge the efficiency of the flame and obtain the correct size of the burner parts. We understand that the makers supply a test case containing a large assortment of parts, so that the best combination for any particular gas can be found by trial.

Gas Lighting and Ventilation.

The Gas Light and Coke Co. send us, as we go to press, some particulars extracted from the *Medical Magazine* regarding the report of Dr. F. S. Toogood, Medical Superintendent of Lewisham Infirmary, on the HYGIENIC ASPECTS OF GAS LIGHTING AND HEATING. Dr. Toogood finds that "modern incandescent burners can be used for lighting without any detriment to health." He has also experimented with gas stoves, and considers that, in a well-ventilated room, they are quite satisfactory from the hygienic point of view.

We have received from **Messrs. Siemens Brothers Dynamo Works, Ltd.** (Caxton House, Westminster, S.W.), a very complete and well-indexed price list of continuous and alternating current GENERATORS AND MOTORS. The various types of motors each have their special characteristics described, and hints are given as to choice of a machine for any particular purpose. A large section of the catalogue is devoted to starters and other accessories, and here again the technical points to be remembered in selecting a starter are clearly set forth. The whole production, with its illustrations and diagrams, is in excellent style throughout.

The British Westinghouse Electric and Manufacturing Co., Ltd. (Trafford Park, Manchester), have sent us a set of leaflets dealing with their switchboard and portable AMMETERS AND VOLTMETERS, together with a reprint from *The Electrician*, in which mention is made of an improved type of moving-iron instrument brought out by the above company. A curve is given showing the very evenly divided scale obtained on this instrument, by the use of a specially shaped armature, and comparison is made with the scales previously obtained in moving-iron ammeters.

Other Lists received:—

Messrs. British Thomson Houston Co. Ltd. (Rugby), starting Rheostats. **Messrs. W. J. Fraser & Co., Ltd.** (98, Commercial Road, E.), apparatus for sterilizing air in hospitals and other public buildings. **The Metallic Seamless Tube Co., Ltd.** (Wiggin Street, Birmingham), a descriptive pamphlet dealing with the Bayliss "Grip" conduit system. **Ruston, Proctor & Co., Ltd.** (Lincoln, England), gas engines and suction gas producers.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

There are a considerable number of references in the British press to the discussions at recent meetings of the Illuminating Engineering Society on **library and school lighting.** There have also been several papers of special interest analyzing the **nature of glare,** &c., at meetings of the American Illuminating Engineering Society; the complete text of these is not yet available, but reference to them is made in several New York electrical journals. Special mention may be made of the article in *The American Gaslight Journal* (Feb. 13th) summarizing the recent work of the Illuminating Engineering Society in this country. The last number of the transactions of the American Illuminating Engineering Society contains the complete paper by W. BASSET JONES on the **decorative lighting** of the Alleghenny County Soldiers Memorial. It will be recalled that the feature of this installation was the use of a coloured glass ceiling, and the production of colour-harmonies in the light, from flame arcs, mercury lamps, &c.

One other item in the United States which calls for special mention is the description of the **elaborate fixtures** in a church in New York in *The Illuminating Engineer* (N.Y.). These substantial pedestals, terminating in diffusing globes, do not seem to be so frequently met with in this country.

Other articles in the same journal include an account of the **lighting of a printer's premises** by tubular lamps with reflectors. The illumination is secured partly by indirect ceiling lights, and partly by means of trough reflectors placed above the compositors' frame so as to concentrate the illumination downwards, and yet completely screen the eye.

LASSER (*E.T.Z.*, Jan. 19th) deals with the special problems in illumination arising in **lighting goods trains, trucks,** &c., while they are being loaded at the railway station. Strong portable lamps are here in request. Electric incandescent lamps, attached to long flexibles, can be plugged on to protected sockets just below the platform, or can be hooked on by means of bamboo rods carrying connexions to bare mains carried through the shed at a suitable height. Thus the supply can readily be tapped and light secured at any desired point.

Among contributions dealing mainly with instruments and apparatus, we may note that by CZUDNOCHOWSKI (*Phys. Zeitschr.*, Jan.), who describes in detail means of projecting the image of luminous solid objects on the screen; this can even be applied to exhibit diagrams, trace out vibrations, and show experiments of all kinds, even such phenomena as phosphorescence being stated to be capable of demonstration.

H. KRÜSS (*J.f.G.*, Feb. 11th) describes a new form of **contrast photometer,** in which a prism is utilized, but angle errors are avoided. It is essentially a modification of a device by Wild previously referred to in these columns.*

H. DU BOIS (*Zeitschr. f. Instrumentkunde*, Jan.) describes a form of instrument intended to supply powerful monochromatic light, based on a direct vision prism combination. By a slight adjustment light from any part of the spectrum can be secured.

ELECTRIC LIGHTING.

Most of the contributions of the month on electric lighting deal with general questions, and do not call for any but passing comment.

F. BRANDT (*A.E.G. Zeitschr.*, Jan.) has an interesting account of the **stage lighting of a Berlin opera-house.** The article contains full details of the switching gear, rheostats, &c. An article by O. BRANDT (*Elek. Anz.*, Jan. 13th) consists in the reproduction of a large number of life tests of metallic filament lamps of different kinds. B. DUSCHNITZ (*Elek. Anz.*, Jan. 13th) summarizes recent patents on the subject of **mercury vapour lamp improvements.** These are mostly devoted to starting rocking devices, &c.

An editorial in *The Electrical World* (Feb. 2nd) comments on the progress made in flame arcs in Europe, special attention being devoted to the enclosed flame lamp; the figures quoted are taken from Prof. W. E. Marchant's paper before the Illuminating Engineering Society this session. Progress in enclosed flame arc lamps is again dealt with in a serial article in the *Zeitschrift für Beleuchtungswesen* (Jan. 30). A recent patent taken out by A. Denman Jones is mentioned.

* *Illum. Eng.*, Lond., vol. i., 1908, p. 825.

M. LEBLANC contributes a general account of the **Moore Tube Light** (*Rev. Électrique*, Jan. 7). A special departure of this kind is the **Neon Tube Lighting** (*Elek. Anz.*, Jan. 22). Tubes of this gas are stated to glow with a vivid orange-red colour when subjected to an electrical discharge and, it is, thought, will therefore be serviceable for spectacular as a complementary to the mercury vapour lamp.

An article on **Flat Rate Window Lighting** in Massachusetts (*Elec. World*, Jan. 26) contains some striking photographs of shop lighting. The characteristic of each is the concealment of the actual sources behind screens and draperies so that the light is shed upon the goods, but the lamps themselves are not seen.

C. L. KINSLOE contributes some further correspondence relating to his experiments on the effect of the shape of the voltage wave on the performances of metallic filament lamps (*Elec. World*, N.Y., Feb. 2nd).

R. SCOTT (*Elec. Rev.*, N.Y., Jan. 28th) replies to some remarks of L. Bell regarding the **design of incandescent lamps,** the adoption of **standard dimensions,** &c.; he contends that the present precautions taken in this respect do not suggest lack of foresight, and that lamps have already been brought to a high stage of uniformity in the United States as a result of the standardization of the various tools and guages used in manufacture. As an instance of the exactitude demanded, he refers to a common type of shade in which it is essential that the lamp bulb must just fit into an aperture in a frosted glass pla'e; yet lamps of different make can be interchanged and there is never a misfit.

GAS, OIL, ACETYLENE LIGHTING, &c.

Several recent editorials on gas lighting demand attention. Both *The Journal of Gas Lighting* and *The Gas World* make special reference to the progress of high-pressure gas in Birmingham. The former journal also deals with the question of the DESIGN OF THE HEADS OF INVERTED BURNERS and glass shades. Trouble has been experienced through occasional breakage of globes. This has been traced to the unequal expansion of the glass and the metal collar gripping the shade, and the problem is one of designing the burner head so that there is play for unequal expansion and stresses of this kind. The other question dealt with editorially is a paper by F. S. TOOGOOD regarding the hygienic aspects of gas lighting, as regards products of combustion, &c. The author's figures are quoted to show that no difficulties in this respect are experienced with modern gas appliances.

W. EISLE (*J.f.G.*, Feb. 4) reviews the **future of gas lighting,** singling out as one of the problems for the next few years the provision of a perfectly reliable means of automatic ignition. He also looks forward to the time when every gas supply will have both high and low pressure gas available, and refers to the future of the gas turbine, and the use of gas for balloon filling.

G. HIMMEL (*J.f.G.*, Feb. 11) describes fittings for enabling high-pressure gas lamps to be suspended centrally in the streets, and then lowered to the side of the road for attention; this is done by making the pipes in a series of several jointed links, and the method is stated by him to be both elegant in appearance and successful in practice.

Automatic Lighting is again to the fore. "A Dutch Engineer" (*G.W.*, Jan. 28) inquires whether any pneumatic system of controlling public lights is in use anywhere. He also proposes to get over some of the difficulties of automatic control by adopting the system of lighting by hand torch, but extinguishing by a pressure wave, thus avoiding any need for a pilot jet.

Reference is also made to a modification in the "Telephos" system, enabling a cluster of lights to be turned on or extinguished singly; and the new "Automaton" device is described, its special advantages being demonstrated by a series of pressure charts. Before leaving this subject mention should be made of the paper by C. F. MASON, delivered at the American Acetylene Convention, on AUTOMATIC STREET LIGHTING BY ACETYLENE; this and several other interesting papers read at this convention are referred to in acetylene journals, and it is contemplated that they will be dealt with shortly in this journal.

Acetylene contains some data on the protection of acetylene generators, &c., from the effects of frost. Considerable attention is also devoted to a recent acetylene accident; this is ascribed to imperfect workmanship. The various letters on the subject emphasize the need for expert work, and especially the avoidance of composition piping, which is apt to be gnawed through by rats, thus leading to a leak.

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The Lighting of Public Libraries (Discussion of the Illum. Engineering Society of London, *J.G.L.*, Feb. 7).
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ELECTRIC LIGHTING.

Brandt, F. Die elektrische Bühnenbeleuchtung im königlichen Opernhaus in Berlin (*A.E.G. Zeitschr.*, January).
Brandt, O. Dauerversuche an Metallfadenlampen (*Elek. Anz.*, Jan. 15).
Duschnitz, B. Die neuern Bestrebungen zur Verwollkommunung von Vakuum-Metalldampflampen (*Elek. Anzeiger*, Jan. 15).
Editorial. Improvements in Flaming Arcs (*Elec. World*, N.Y., Feb. 2).
Kinsloe, C. L. Voltage-wave Distortion and the Life of Incandescent Lamps (Corres., *Elec. World*, N.Y., Jan. 19).
Leblanc, M. La Lumière froide de Moore (*Lumière Electrique*, Jan. 7).
Scott, R. Foresight in the Design of Incandescent Lamps (*Elec. Rev.*, N.Y., Jan. 28, Corres.).
Neonbeleuchtung (*Elek. Anz.*, Jan. 22).
Bogenlampe mit eingeschlossene Lichtbogen (*Z. f. B.*, Jan. 30).
Flat-rate Window Lighting in Massachusetts (*Elec. World*, N.Y., Jan. 26).

GAS, OIL, ACETYLENE LIGHTING, &c.

Clark, W. G. Cultivation of Friendly Relations between the Public and Lighting Companies (*Am. Gaslight Jour.*, Jan. 30).
Editorials. High-Pressure Gas in Industry (*J.G.L.*, Jan. 31).
Inverted Burner Heads (*J. G. L.*, Jan. 31, 1911).
Laying the CO_2 Phantom (*J.G.L.*, Feb. 21).
Eisele, W. Die Zukunft des Leuchtgases (*J. f. G.*, Feb. 4).
Himmel, G. Elegante Strassenbeleuchtung an Strassenüberspannungen (*J. f. G.*, Feb. 11).
Pattison, J. Marine Lighting, Here and Abroad (*Acetylene Journal*, February).
Powney, W. E. F., and Coste, J. H. Testing Incandescent Gas Mantles (*J. G. L.*, Feb. 7).
Mason, C. F. Automatic Acetylene Street Lighting (Paper read before the Am. Acetylene Convention, 1910, *Acetylene*, February).
Toogood, F. S. Hygienic Aspects of Gaslighting and Heating (*J.G.L.*, Feb. 21).
The New Welsbach "Intenso" Lamp (*Am. Gaslight Jour.*, Jan. 23).
Automatically Lighting Street Lamps (*G.W.*, Jan. 28).
The Automaton Lamplighter (*J.G.L.*, Feb. 7).
Birmingham High-Pressure Gas Section (*G.W.*, Jan. 28; *J.G.L.*, Jan. 3).
Neuere Verfahren zur Herstellung von Gasglühkörpern (*Z. f. B.*, Jan. 30).
The Protection of Acetylene Apparatus from frost (*Acetylene*, February).

CONTRACTIONS USED.

Elek. Anz.—*Elektrotechnische Anzeiger.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
J. G. L.—*Journal of Gaslighting.*
T. I. E. S.—*Transactions of The Illuminating Engineering Society (United States).*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

Some Publications Received.

The Journal of the Municipal School of Technology, Manchester. This volume is a record of investigations undertaken by members of the teaching staff and students of the above college. The variety of subjects covered, as indicated in the contents, is remarkable. We notice several electrical and mechanical engineering investigations, a considerable amount of chemical research, and even such a recondite study as the microscopic examination of the colouring matter of mummy wrappings. The volume is well illustrated, and the tables and diagrams throughout are very clear.

Electric Wiring, Fittings, Switches, and Lamps. By W. Perren Maycock, M.I.E.E. (Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C.). This is a new edition of the well-known work on wiring, &c. The book aims at explaining in a practical manner for electric light engineers, wiremen, and students the electrical action and connexions of the various appliances used by the consumer of electrical energy.

Nachträge zur Theorie des Kugelphotometers. By Erich Dyhr. An account of some researches on the accuracy of the globe photometer, undertaken at the suggestion of Prof. W. Wedding, and reprinted from the *Elektrotechnische Zeitschrift.*

Among other publications we have also to acknowledge the receipt of the following: *The Journal of the Royal Society of Arts, The Proceedings of the Physical Society of London, The Architectural Association Journal, The Technical Journal, The Transactions of the South African Institute of Electrical Engineers, The Proceedings of the American Institute of Electrical Engineers, The Proceedings of the American Academy of Arts and Sciences, The American Chemical Journal, The Transactions of the American Electrochemical Society, The University of Illinois Bulletin, Jahrbuch der Radioaktivität und Elektronik, Atti della Associazione Elettrotecnica Italiana,* &c.

(To many of these publications we mean to make fuller reference shortly).

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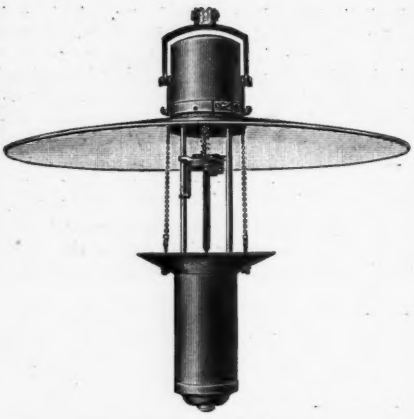

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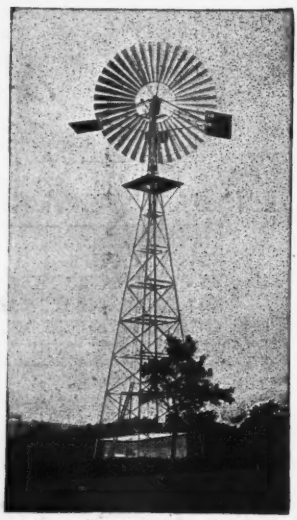

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The ILLUMINATING ENGINEER

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Edited by LEON GASTER

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EDITORIAL.

School Lighting—Some Conclusions.

THE last two meetings of the Illuminating Engineering Society, devoted to the subject of School Lighting, served again to demonstrate the great value of the impartial platform which the Society affords. It is true that a knowledge of what constitutes ideal school illumination has yet to be gained, and the results of tests presented at these meetings are to be regarded as merely suggestive, and not as constituting anything in the nature of a comprehensive report. Still, some valuable conclusion can be derived from this discussion, and we therefore again take the opportunity of making a brief summary of some suggestions which seem to deserve immediate attention:—

Complete Absence of Glare essential.

The matter of avoiding glare from inconveniently placed or imperfectly shaded bright sources of light is a very vital one in schools. It is usually a comparatively simple matter to avoid this defect, and yet experience shows that in a very large number of schools and colleges the lighting is open to objection from this standpoint. In lecture and classrooms it is still not unusual to find such lights hung in the direct line of sight of those at the back of the room; sometimes unsatisfactory forms of shades which only incompletely cover the filament or mantle are used; in certain cases also the positions of the lights appeared to be such that glare was almost inevitable.

The importance of avoiding methods of lighting that are apt to weary the eyes of teachers of children in schools, or students in colleges, is so great that it may be suggested that *no unscreened unduly bright source should be visible in the direct line of sight from the desks or from the blackboard.*

Sufficiency of Light for Reading.

It was generally admitted in the discussion that sufficient illumination for reading was quite as important in schools as in libraries; in the case of young children, to whom reading and writing constitute a special effort, it is possibly even more so.

There was a consensus of opinion that the old suggested minimum of 1 foot-candle was too low, and that, in the light of present-day experience, *an illumination of at least 3 foot-candles was desirable.* It was further agreed that for work that is specially trying to the eyes—for example, sewing, reading sheet music, shorthand, drawing, fine metal work, &c.—at least, 4-6 foot-candles should be provided.

Special Local Lighting needed for Blackboards, &c.

The first requirement in a classroom or lecture theatre is the provision of an even, sufficient, and pleasantly diffused general illumination, without glare. But, in addition, it was suggested that the provision of special local illumination for the teacher's benefit would often be desirable. For example, the illumination on the blackboard may profitably be strengthened to about twice that prevailing in the rest of the room so as to enable students at the back to distinguish the diagrams and chalk writing with ease and comfort. High local illumination may also be influential in assisting the concentration of attention on the board. Similarly, when special experiments, &c., are arranged on the demonstration table, their effect is rendered more easily visible by strong light, and the accentuation of brightness helps to make this the centre of interest in the room.

Blackboard lighting requires care in several respects. The lights used for the purpose should be completely screened from the eyes of students (like the footlights on the stage), and should be so arranged that there is no glare from the blackboard in the form of light directly reflected from its surface. It was also pointed out that there is a need for reflectors scientifically designed for this purpose, for unless the light is efficiently distributed, the expenditure becomes heavy. Since the effect of writing on a blackboard depends on the contrast between the dark surface and the white (or coloured) chalk, it is evident that the choice of a material for blackboards giving a dead black surface is an important item.

Further Study Needed.

A glance at the data collected regarding the consumption of energy in different schools and colleges shows that considerable deviations exist in this respect. It would not be easy to say, without exhaustive tests of different systems, what is the absolute minimum consumption consistent with ideal illumination. But this much may be said, that one frequently finds schools and colleges in which the consumption and expenditure far exceeds that in others, and in which the results as regards illumination are nevertheless greatly inferior. We hope that such cases will be made the subject of special study with a view to securing more perfect conditions.

As regards the relative merits of inverted and direct lighting, or combinations of these systems for different purposes, much has yet to be learnt. There are also unexplored possibilities in the direction of special contrivances for certain kinds of work, for showing up experiments and demonstrations to the best advantage, &c. It may be suggested that such matters as these might profitably be made the subject of study in some of our engineering colleges and institutions. The professors and staff in such cases may be expected to have a special technical interest in the subject, and they have also frequently exceptional opportunities for experiment. It may be added, moreover, in these cases the question of economy in energy-consumption is not a very vital one, as

many institutions produce their own electrical energy and can afford to arrange the illumination on a generous scale.

In any case it can hardly be doubted that, both in schools and colleges, the present conditions might often be very materially improved, and we trust that the various representatives of educational and medical authorities who took part in the discussion, will make their influence felt in the right direction. We hope that on some future occasion there will be an interesting record of further co-operation, experiment, and progress in this respect to be placed before the Illuminating Engineering Society.

Illumination and the Prevention of Accidents.

The effect of good conditions of illumination in promoting freedom from accidents and casualties has frequently been the subject of comment in these columns. The importance of good factory lighting in general, and of adequate illumination of dangerous machinery in particular, were both the subject of special comment at the Congrès International des Maladies Professionnelles in Brussels last year, and at that time we ventured to express the hope that this matter would receive early attention from the Home Office authorities in this country.

We have now before us the newly-issued Report of the Departmental Committee on Accidents in Factories and Workshops. The official account of the evidence taken by the Committee has yet to be published, but it is very gratifying to observe, from the Report presented, that the effect of good illumination as a preventative has received special attention.

We notice, from the statements of representatives of the Society of Iron Founders, the Brass Workers' Society, and other witnesses, that inadequate illumination has been a frequent ground of complaint. Several inspectors make remarks to the same effect, Miss Squire, for example, stating that inadequate lighting is a "very frequent cause of accident, and of grave danger, especially in the smaller printing works and hardware factories in the Midlands." An important point to notice is that employers also expressed their consciousness of the importance of efficient lighting.

In conclusion, the report emphasizes the need for consideration before adopting any specific standard of illumination, "but, even before such a standard can be arrived at, it is recommended that the inspectors should be given general statutory powers to require adequate lighting in all places where work is done, and in all places which are a source of danger by reason of insufficient lighting."

We think that the moderation of this recommendation, and the expressed intention of proceeding with care in the matter of laying down precise requirements, will meet with general approval. We are all conscious that much spade work is necessary before exact or detailed regulations can be framed. Meantime all that can be desired is for a general interest to be taken in the matter, and the requisite data gradually accumulated. We feel sure, too, that in framing moderate suggestions of this nature the Home Office will continue to receive, as they have already done, the support and co-operation of all far-sighted employers. There can be no question that the employer, quite as much as the workman, stands to lose by poor lighting. He is, therefore, most anxious to receive practical suggestions as to how the lighting can best be arranged, and it may be anticipated that inspectors with the necessary experience and qualifications will be able to help him considerably.

It only remains, therefore, to thank the Home Office for the steps they are taking to improve the conditions of illumination in factories. We have no doubt that, with a more perfect know-

ledge of what constitutes good illumination for different classes of workshops, and the introduction of simple and yet efficient methods of testing, regulations will be framed by which employer and workman alike will profit. At the same time we may hope that the question of the standard of illumination required for different classes of work will be settled in due course and will present no insuperable difficulties, especially as we have at our disposal the experience of other nations who have framed regulations on this basis. In conclusion, we may add that the Illuminating Engineering Society can render material assistance in this direction, and we have reason to believe that full advantage of its services will be taken.

The Proposed Opto-Technical Institute.

It will be recalled that the Education Committee of the London County Council, after a long and searching investigation into the conditions of instruction in optical science in this country, ultimately determined to advocate the erection of a central institute to deal with this subject at a cost of £30,000. A meeting of prominent opticians and others interested was subsequently held, and warm approval of the scheme was expressed. The report of the Education Committee is now before the Finance Committee of the London County Council, so that it may be anticipated that the plans for the new institute should shortly assume a concrete shape.

We believe that any one who takes a wide and intelligent view of the needs of the optical industry in this country must appreciate the valuable work that might be done by such an institution. The great progress made by Germany in this essentially scientific branch of industry has been phenomenal. For an explanation of this success we need hardly look further than the magnificent organization of scientific research, and the excellent facilities for instruction in the underlying principles of optics which prevail in that country.

The lesson to be drawn is that the rule of thumb in scientific matters is dead. It is no longer possible for a manufacturer in a highly skilled trade to maintain his position without a knowledge of the latest scientific developments, or without being himself constantly interested in active research.

An institution of the kind proposed might be of immense benefit in acting as a centre for scientific information, and collecting together data regarding the various special branches of optical manufacture. At present there is admittedly a need for a centre of this kind. We should like to see included in its work not only the study of the many specialities in optical instruments, but also of problems in connexion with colour, illumination, light measurement, and the like. It is gratifying to observe that this appears to be the intention of those responsible for the scheme, and also that the work of the institute will be facilitated by linking it up with other existing institutions doing kindred work, such as the National Physical Laboratory, the Imperial College of Science and Technology, &c. We trust that the conditions enabling work to be carried out at the Institution will be made as wide and liberal as possible.

The manufacture of apparatus and instruments for the measurement of light and illumination, which is an essentially optical problem, is already receiving an increased amount of attention, and we may confidently anticipate that in the near future the importance of this subject will be even more fully appreciated. We hope, therefore, that due recognition will be given to this and allied matters of interest to illuminating engineers by adequate representation on the proposed Council of the Institution.

LEON GASTER.

Review of Contents of this Issue.

THE Technical Section opens with the first part of an article by MR. W. BASSETT JONES, JUN., of New York, on the **Lighting of the Allegheny County Soldiers' Memorial.** The article describes the main features of the illumination of this building in which a unique attempt has been made to use the lighting effects as an integral part of the general scheme of decoration. Much attention has been paid to the colour of the various sources of light utilized, and, by combination with special coloured glass, many very beautiful effects of colour harmony are stated to have been obtained, notably in the ceiling of the auditorium. The author also mentions the necessity of making a special study of shadows in order to throw into prominence the architectural features of the building, and he gives instances in which this was apparently accomplished with remarkable effect.

Following this is a note on **A New Method of Measuring Intrinsic Brilliancy,** which DR. H. E. IVES has recently described. The principle consists in balancing the source of light it is desired to measure against a suitable bright background, which can be varied and has previously been calibrated.

The section devoted to the *Transactions* of the **Illuminating Engineering Society** is concerned chiefly with the discussion on **School Lighting** which took place at the meetings of the Society on February 16th and March 14th. (The papers with which Dr. Kerr and Dr. Bishop Harman opened the discussion were printed in our last issue.)

On page 203 occurs the full report of the discussion at the first meeting, and this is followed by the first part of an account of the **Tests of Illumination in Various Public and Elementary Schools** and technical institutions which were carried out by MR. LEON GASTER and MR. J. S. DOW and presented at the adjourned discussion.

The results of these tests seem to show that an average illumination of from 2 to 3 foot-candles is usually secured on the school desks. One common defect met with was the tendency to imperfect shading and glare. Insufficient attention was also paid to the lighting of the blackboard, which in most cases received no special means of illumination.

The report of the adjourned discussion at the meeting on March 14th will be found on page 217.

MR. T. E. RITCHIE showed some slides illustrating the illumination by inverted arc lamps of two technical institutions in London, and gave particulars of some measurements of the lighting which he had made. He thought that Dr. Harman had suggested an unduly low minimum illumination of 1 foot-candle, which could not be sufficient at least for certain classes of work, and he preferred a value of 3 or more foot-candles.

MR. F. W. GOODENOUGH joined issue with Dr. Harman on the question of inverted incandescent burners, laying stress on their greatly increased efficiency; he also advocated the placing of school installations on a maintenance contract in order to ensure proper attention for the burners, which would never be satisfactorily looked after by school-keepers.

MR. J. G. CLARK then showed and described some slides which had been taken by the Gas Light and Coke Co. of gas installations in an elementary school and a technical institute.

DR. E. H. NASH spoke on the subject of **Daylight Illumination in Schools,** and pointed out that the discussion

which had taken place so far, and the results that had been presented, led him to a conclusion that the present square shape of classroom adopted in L.C.C. schools was not the best possible, and he hoped that a change would be made. He also called attention to the harmful use of certain coloured chalks for blackboard purposes which were frequently almost invisible, and yet were used in teaching young children to read.

MR. J. DARCH also advocated a higher order of illumination, and agreed with Dr. Harman's suggestion that special treatment should be accorded to the teacher's part of the room ; in all cases the lights should be effectually screened.

MR. J. ECK likewise advocated an illumination of at least 3 foot-candles for ordinary work, as recommended by Dr. Broca, and MR. V. H. MACKINNEY described the application of his special reflector to blackboard lighting.

The report of the discussion concludes with communicated remarks from MR. SHERARD COWPER-COLES on gold-film reflectors and others, followed by the replies of DR. KERR and DR. HARMAN.

A communication from MR. W. W. WEBB deals with the subject of daylight illumination and its influence on the shape of classrooms. A comparison is made between English and Continental practice in this respect.

On page 239 will be found a further contribution from MR. F. W. GOODENOUGH in which he tabulates the results of tests carried out in some gas-lighted schools, and comments briefly upon the data presented ; some photographs of these schools, taken by artificial light, are also shown.

An article by PROF. L. WEBER (of Kiel) on the **Measurement of Diffuse Daylight in Classrooms** follows. He reviews the work that has been done in this direction in the past, and describes an instrument which he has devised for studying the daylight illumination in a room. The instrument follows the general principle of the Thorner apparatus, but has certain important features which overcome some of the difficulties met with in the earlier instrument (as, for example, the obstruction of light by the head of the observer).

On page 244 will be found a further contribution to the discussion on Library Lighting. MR. L. B. MARKS describes his work in connexion with the **Lighting of the Library of Congress at Washington**; this is specially concerned with the problem of lighting stacks of books having narrow gangways between. Details are given of the method adopted at Washington, particularly the use of time switches by which the lights are automatically switched off after a given interval of time.

A series of **Short Notes on Illuminating Engineering** deal with different aspects of **Shop-Window Lighting**, the **Methods of Charging adopted** by Supply Companies. A device for projecting advertisement pictures on to a screen fixed to the wall of a building is also illustrated and described ; another note refers to a plea for the issue of polar curves of distribution by lamp makers which Mr. J. G. Clark made recently in the correspondence columns of one of the technical journals.

Among other articles we may note an account of a recent **Visit to the National Physical Laboratory**; an interesting experiment was shown on this occasion, serving to demonstrate that the eye could perceive a light as weak as one millionth of a candle-power.

Another article deals with the Effect of Alternating Current on the performances of Electric Glow-lamps, &c. Mathematical investigations show that results almost identical with those on continuous current should be obtained.

At the end of the number will be found the usual TRADE NOTES, REVIEWS OF BOOKS, and REVIEW OF THE TECHNICAL PRESS.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

The Lighting of the Allegheny County Soldiers' Memorial.

By Bassett Jones, Jun.

[Abstract of paper read before the Illuminating Engineering Society in the United States, December, 1910.]

Architecture and Construction.

The Allegheny County Soldiers' Memorial is located in that district of Pittsburgh known as Oakland.

Fig. 1.—View of Memorial Corridor, taken at night.

The structure is an imposing pile of majestic proportions. The main auditorium, is a large room 120 ft. clear span in the square and 65 ft. from the centre of the floor to the ceiling. The floor slopes to a stage at the rear. A large gallery extends around three sides of the room.

The auditorium is lighted during the day by seven immense one-piece plate-glass windows in each of the four walls. These windows are 20 ft. high, extending

from a decorative band above the gallery to within 3 ft. of the ceiling.

The ceiling of the auditorium is broken into panels by deep plaster soffits covering the bottom chord of the trusses which support the floor of the banquet hall above. These panels are suspended from the steel work in the banquet hall floor and are thus only indirectly supported by the trusses. Each panel is entirely separated from the soffits by a slot 6 in. wide, and thus hangs free within the frame formed by the projecting trusses. The depth of these trusses, 12 ft., made it possible to obtain a clear space above the panels 6 ft. high which was used in the illumination of the auditorium as will be described hereinafter.

The banquet hall, which is reached by elevators and staircases in the four supporting corners of the structure, is 35 ft. from floor to ceiling and is 74 ft. square. The ceiling is divided into 49 square coffers, about 2 ft. deep, the top of each coffer consisting of a decorative glass sash.

Nature of Scheme of Decoration.

While the exterior of the building is almost severe in its simplicity, the interiors, particularly the foyer, memorial corridor, auditorium, and banquet hall, are rich in decoration and ornament and are exceedingly rich in colour.

It is known that the Greek architects were lavish in the use of bright colours, both on their exteriors and interiors—something like it was done by the Romans at Pompeii and by the Italians of the fifteenth century. The use of elaborate colour schemes has fallen more or less into disuse during modern times, but in this case so carefully have the tones been selected and blended, so thoroughly have the laws of colour harmony been followed, that the effect has excited general admiration. The building, in short, makes a successful but daring departure from modern practice.

The harmonizing value of black either by itself or in mixture with other pigments is entirely omitted from the colour scheme, with the idea in mind that the unavoidable deposits from Pittsburgh's smoky atmosphere would soon introduce this tone.

Pictures can give one no conception of the colouring. It must be seen to be appreciated. To make this evident, examine the auditorium ceiling. The pattern on the truss soffits is bright yellow, the background red. The mouldings at the soffit heads are light blue and yellow. The panels are a soft opalescent green. The sashes have pale green cross-bars, and carmine mullions support the individual panes, which are gold amber. About the cap of the four great corner pilasters are carmine mould bands. The pilasters themselves and the general tone of the walls are pale purple—almost lavender. But no description can convey the least idea of the tones employed.

General Features of the Illumination.

In the case of the Soldiers' Memorial a striking step has been made in using the illumination itself—not only the light sources, but the actual light effects—both in colour and character, as an integral part of the decorative treatment. The light not only enables one to see the design, but of itself becomes a part of the design. The author believes he is correct in saying that never before has this idea been intentionally carried to such an extent. Practically speaking, the interiors of the building have been designed with the effects of the illumination and the practical demands of the lighting equipment kept constantly in mind. The purpose was to use the electric lamp in such ways as to give the best possible value to the decorative quality of artificial light, combining in the general colour scheme the colours of light emitted by various forms of light sources so as to produce a harmonious effect. That the result is dignified and beautiful is proved by the effect on the audiences occupying the auditorium.

It is, of course, only in comparatively few instances that the use of coloured light in the design can be attempted, but there are several interiors, notably in theatres and other similar audi-

toriums where some such treatment would have been desirable.

The problem, then, was to produce in these rooms a certain arrangement in light colours that would both take its place in the architecture and serve the utilitarian purposes of making the design perfectly visible as well as fulfilling the needs of the uses to which the rooms would be put. Fortunately, the architects' appreciation of the value of light and their intimate knowledge of its limitations—the latter, an often

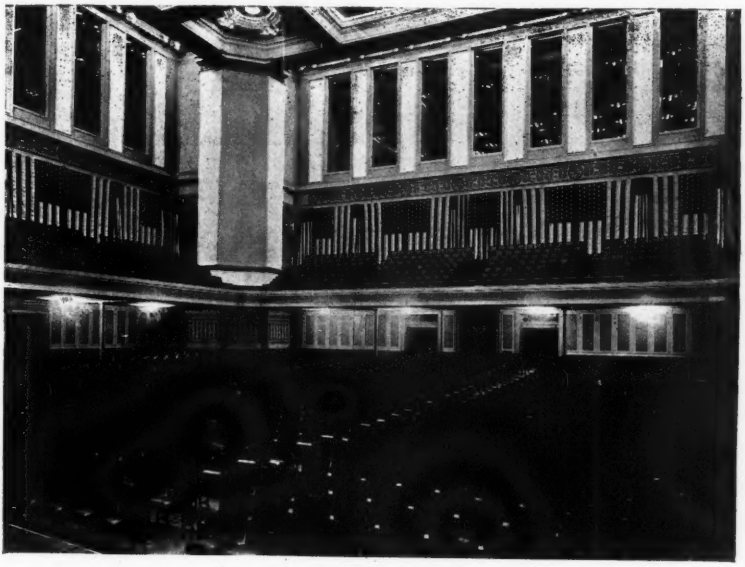


FIG. 2.—View of Auditorium from stage.

neglected aspect of the problem of interior illumination, by the way—made the working out of the solution both interesting and pleasant. The effect of shadows was studied with great care and results in a sharpness of detail and a correctness of perspective under artificial light that has not often been obtained. This is particularly true of the fine relief ornamentation on the auditorium ceiling, which in spite of the great distance from which it is seen, stands out with greater distinctness under artificial light than by daylight.

PRELIMINARY WORK RELATING TO ILLUMINATION.

The results required of the illuminating equipment were so varied and so novel that the writer found himself quite lacking in data applicable to the problem.

In order to plan intelligently the engineering features of the installation it was apparent that a practical study of reflection, absorbtion and diffusion of light by various forms and kinds of glass, and a similar study of reflection of light from various opaque surfaces were essential; it was also necessary to carry on a careful investigation of the effect of screens made of commercial coloured glass.

One of the principal requirements of the installation was the partial lighting of the auditorium and the entire lighting of the banquet hall through sashes of glass let into the ceiling construction. It was demanded that the flux through these sashes should be so distributed that there should be nothing in their appearance to lead the beholder

to appreciate the fact that the light originated at given points above them. There must be no appearance of "spots" due to the image of the illuminant or the intrinsic brilliancy of the light units employed. Furthermore, in order to enable the other features of the ceiling design to take their proper place in the ensemble, it was necessary to avoid all appearance of great intrinsic brilliancy in the light source and so to direct and distribute the light as to avoid loss of shadow. Again, the colour of the light must be suited to the colour of the surface illuminated, and not disturb the colour balance, and, lastly the colour of the light source itself must harmonize with the modified colours of the surrounding architecture. This was no simple problem.

It will be at once evident that there are two controlling factors in this case; first, the kind of glass used in the sashes and, second, the arrangement of the lamps with relation to the glass surface. Several model reflectors with reflecting walls extending down to the edge of the experimental sash were therefore built of white cardboard. The writer eventually succeeded in avoiding "spots" or streaks of high brilliancy without excessive loss of light by the use of specially designed reflectors and window glazing.

The colour scheme in the ceilings of both the auditorium and the banquet hall required that the colour of the lighted sashes be a golden tone. This colour could be obtained in two ways: first, by using a sash glass containing relatively little colouring matter, thus reducing the loss through absorption, and a low-efficiency lamp giving a maximum of light in the yellow, or, second, by increasing the colour in the sash glazing and employing a high-efficiency lamp giving a relatively white light. The best results obtainable with commercial lamps resulted from the combination of tungsten lamps and a sash glazing of amber tint.

The carbon arc lamp was considered and abandoned due to the inherently low efficiency of the alternating current lamp and the great loss in the sash due to excessive colouring matter required to correct the colour of the light. The flame arc would be too noisy and in addition its flickering would destroy the solid luminous appearance of the sashes. Furthermore special ventilating arrangements would be necessary to carry off the gases generated and the constant attention and trimming would be a source of expense. The use of arc lamps was also mitigated against by the necessity of employing a large number of small light units so that the failure of several lamps or the blowing of a fuse would not produce noticeable effects.

The painting of the interior of the reflectors received much attention and various samples were tested until a highly efficient reflecting and diffusing surface was obtained, the finishing coat of which consisted of an imported zinc oxide ground in turpentine only. Great importance was attached to the fact that this zinc oxide thus mixed retains a pure white colour over a long period, and maintains a high reflection co-efficient.

Having thus determined the form of the equipment and the character of glass to be used the next point to be taken up was the quantity of flux needed in each case. This could be found approximately by the flux method, assuming certain intensities of incident light on the ceiling, walls, and floor. Certain definite requirements as to the illumination over certain areas had to be met, however, and a question arose as to the possibility of obtaining these values of illumination with a finite surface source emitting a given flux distributed in a certain way. The writer, therefore, made a study of such sources and obtained certain formulæ for calculating the density of light flux. The results of this study, such as they are, have been presented in two papers already published in the *Transactions*, namely, 'Mathematical Theory of Finite Surface Sources,' April, 1909, and 'On Finite Surface Sources,' May, 1910.

Lighting of the Auditorium.

The view of the ceiling, which is the principal architectural feature of this room, could not be obstructed and hence in any case the use of hanging

lighting fixtures had to be avoided. The treatment of the ceiling is controlled by the light centres, which are also architectural centres when the room is lighted by daylight from without. These nine centres consist of circular panels of rich pierced plaster ornament above each of which are suspended two 18-amp. flame arc lamps, so located and equipped as to cause the plaster lines to stand out in bold relief against a brilliant flickering background. The general effect is that of a scintillating jewel of intricate pattern. One of these circular panels forms the central feature of each of the large panels into which the entire ceiling is divided, as before mentioned, by the deep beam soffits under the steel trusses supporting the floor above.

A group of glass sashes is arranged around each of the flame arc panels and forms a design of geometrical surfaces broken up into small figures by the sash frames. A box reflector of the type above discussed is placed over each sash.

Each of the main rectangular panels, consisting of a flame arc centre and its group of sashes, is framed by a concealed nitrogen vapour tube lamp provided with a reflector that projects the light through a slot entirely surrounding the panel. Each panel is thus bordered by a band of rose-coloured light.

The ornamental plaster mullions separating the sashes in each panel are provided with plaster rosettes equipped with exposed incandescent lamps employed to accent architectural features and show off the elaborate decorative treatment of the plaster work.

Glass panels are located close to the side walls one over each window, and over each is provided a parabolic reflector containing a 400-watt mercury arc. The light from these lamps is directed against the walls of the room and through the windows, and is so modified by the glass in the panels as to acquire a pale sky blue tone.

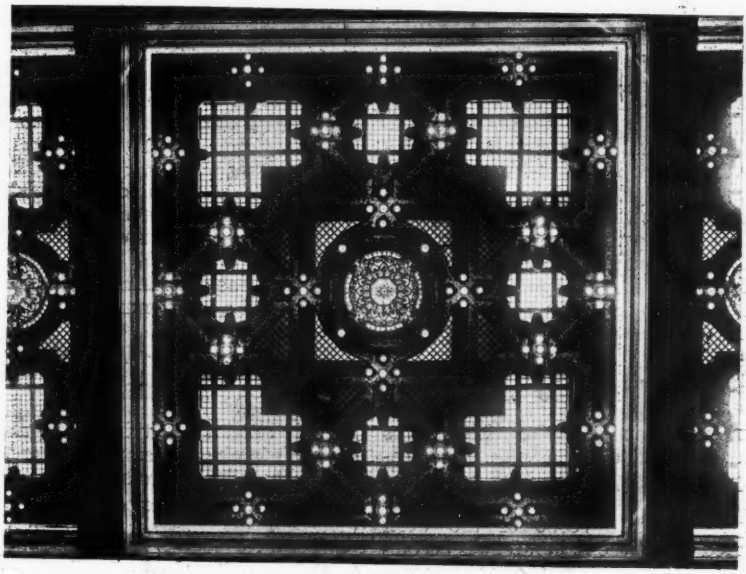


FIG. 3.—Ceiling of Auditorium, taken at night.

No one who has not seen this room lighted can imagine the grandeur of the effects, both from the interior and the exterior of the building. As one approaches the building from without the glory of the ceiling is seen only through the streams of light flooding

from the windows between the columns of the majestic façade. The full splendour of the interior is perfectly set off by the artificial light. The wonderful colour treatment of the walls receives a new interpretation, becoming soft and rich in the flood of golden light that is thrown upon it. Each of the large panels seems to be suspended free in the space marked out for it by the beam soffits, while the entire ceiling is apparently framed by a border of soft moonlight.

(*To be continued*).

A New Method of Measuring Intrinsic Brilliancy.

DR. H. E. IVES has recently described* a new method of measuring the intrinsic brilliancy of artificial illuminants. The main principle of this device consists in observing the source which it is desired to measure against a background whose intrinsic brilliancy can be varied, and which has been previously standardized. The intensity of the background is adjusted until the filament, or other source of light placed in front disappears, thus indicating that its intrinsic brilliancy is the same as that of the background.

The background found to be most satisfactory is a slightly magnified image of a Nernst glower. The current corresponding to a given intrinsic brilliancy of the glower is previously determined, and thus becomes a measure of the intrinsic brilliancy of the source under test.

In cases, however, when the brightness of the source falls below 200 c.-p. per sq. in., the method of changing the brightness of the standard by varying the current could not be used, as the Nernst glower would not operate. In such cases, therefore, a pair of Nicol prisms were inserted and the brightness of the glower image corresponding to their relative position could be calculated.

Dr. Ives has determined the intrinsic brilliancy of a large number of sources by this new method.

* *Elec. World*, vol. lvii., p. 438.

A Visit to the National Physical Laboratory.

THE annual reception of visitors was held at the National Physical Laboratory on Friday, March 17th, when the various departments were open for inspection. The scope of the work carried out at the Laboratory is becoming very wide, as the programme furnished to visitors clearly indicated. The electro-technical department in particular is finely equipped for the large variety of tests which it is called upon to carry out.

In the photometric laboratory, which has been previously described in this journal, the visitors had an opportunity of inspecting the various lamp-testing appliances, including the long track photometer used in measuring the candle-power of arc-lamps. In the room in which life tests on glow-lamps are recorded was to be seen the Tyrrill automatic voltage regulator for maintaining constant pressure on the racks whilst life tests are in progress.

One interesting experiment shown was intended to demonstrate the minimum intensity of light perceptible to the eye. Visitors were introduced to a dark room and shown a faint spot of light, which though distinctly visible was stated to be only one millionth of a candle-power. This method of testing has an important bearing on the perception of lights at a distance by vessels at sea.

An experimental tank has recently been added to the equipment of the Laboratory, and attracted much attention; this will enable a variety of experiments to be made bearing on the resistance to motion of models of ships towed through the water at different speeds.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

School Lighting—Discussion.

(Proceedings at a meeting of the Illuminating Engineering Society, held in the House of the Royal Society of Arts (London), on Thursday, February 16th, 1911.)

THE PRESIDENT said they had had three communications from what might be termed the medical point of view.* There were a number of gentlemen present who were prepared to speak from other points of view, and in this connection he wished to mention how extremely fortunate the Society was to find that the invitation which had been addressed to other bodies had been responded to. They had several representatives of the Association of Technical Institutions, including the heads of several of them. There were representatives of the Association of Medical Officers of Schools, one representative at least from the London Teachers Association, and by no means least, although he named them last, there were several officials of the London County Council, from other departments than the actual Education Department. There were also two or three medical gentlemen present whom they would be pleased to hear if there were time, on the more specially medical aspects of the case. In fact, they had an *embarras de richesses*. Their indefatigable honorary secretary and his assistant had, on their own initiative, obtained permission from various bodies to examine the lighting of a number of schools, and he would first of all ask one of them to give the result of their investigations.

(The complete data relating to these schools were found to occupy too much space to be conviently included in this discussion; they are now embodied, with additional information since received, in a contribution on p. 209—ED.)

* *Illum. Eng.*, Lond. March. 1911 pp. 154-166.

DR. R. S. CLAY (Principal, Northern Polytechnic) spoke as a representative of the Association of Technical Institutions. He said that experiments had been made at the Northern Polytechnic with inverted arc lighting. At first the makers supplied the carbons the wrong way up, thus the main body of the light was twice reflected and a great deal of it lost. To obtain a good result the lamps are put about 4 ft. from the ceiling, which must be very white. This lighting is especially suitable in drawing offices, because it is almost shadowless. It has been found good in the masonry shop, enabling the undercutting to be distinctly seen; also in shops where work is done on bright curved surfaces, the reflections of an ordinary light from which are very troublesome. As a great deal of light is lost in inverted arcs, in rooms where the above considerations did not weigh, he had replaced them with 100 candle-power metal filament lamps, which electrically gave a much more efficient illumination.

Referring to Dr. Harman's paper, he thought the "distinctness" test for estimating candle-power might be made use of. He had had a small instrument made that afternoon, by which he had been able to estimate the amount of light in different parts of his room. It consisted of a "V" cut in one piece of brass which could be closed by rotating another piece of brass over it, the extent of the aperture being shown by a scale. With regard to Dr. Harman's remarks as to the relative

efficiency of upright and inverted mantles, he had personally found the latter much better. He thought that if a suitable shade could be arranged for them, they would be found on every point Dr. Harman raised, superior to the upright.

MR. C. A. BAKER, M.I.E.E. (Electrical Engineer, London County Council) pointed out that in considering a standard of illumination for classrooms it must be remembered that the rooms are used for many different purposes. In ordinary schools it was the evening class accommodation that had to be considered most of all, and the difficulty of the problem was to adopt one kind of lighting which was at all times economical and yet efficient for the different purposes.

The use of 25-volt lamps suggested by Dr. Harman introduced the question of prime cost of the installation, the illuminating effect being, of course, quite independent of, and in no way related to the supply voltage, except that with 25 volts one can use lamps of smaller candle-power. If a very large number of small points had to be put up, the prime cost would be too high in many cases.

He thought they had solved the problem of getting a cheap installation and a satisfactory light at the Haverstock Hill School. This school, which had been lighted electrically on the same plan as many other recently-built schools, had only been opened a few months.

The lighting of the Charing Cross Road School, to which Mr. Dow had referred, was carried out many years ago, and the most feasible explanation that occurred to him for the peculiar arrangement of the lamps in regard to the benches at the present time was that the original use of the room was of a totally different nature to the present use.

During the past five years he had had occasion to design and supervise the electric lighting of 6 colleges, including the Day Training College, the Central School of Arts and Crafts, the Westminster Technical Institute, &c., 4 Secondary schools, 18 elementary schools, and 2 special schools, making 30 in all, in addition to important alterations and extensions of other educational establishments, and some valuable experience had been gained. He was adopting 50-candle-power lamps for the schools as being generally a useful unit to employ, and for a school to accommodate 960 children the cost was about £320; the total candle-power installed was 7,500, and the price per candle-power installed 10·2 pence, the candle-power per child accommodated being 7¾. The Council's Statistical Officer puts the number of school children in London at 886,000, so that the total illumination required was about 7,000,000 candle-power to light up the County Council schools at the present time. Inverted arc lighting would cost about twice as much to instal, and twice as much to use, so that it will only be rarely used in very special places where a shadowless light is absolutely necessary.

He was pleased to note that Mr. Dow found that a different order of lighting was required for trade schools; for instance, where seamstresses were learning and working on dark cloth one or two foot-candles would be quite unsuitable; five or six foot-candles would be nearer the required amount, and he hoped representatives of other schools than the County Council's schools would speak with regard to this.

In the L.C.C. schools the lamp ends were frosted, and the white opal shade used was a deep one, measuring 14 in. by 7 in.; the top of the shade was open; this materially reduced the weight of the shade, and let out the heat so that the flexible cords lasted longer. The bright filament of the lamp was invisible from every point of the room, this, to his mind, being of the utmost importance.

Nobody in the discussion had given a reason for lighting from the left, but his own suggestion was that it enabled one to avoid reflection from the book surface, which was sometimes noticeable when the light fell from the right, particularly if the paper had a glazed surface.

The systematic marking out of lamp positions in relation to the positions of the desks, as suggested by Dr. Harman, did not take place in practice; the desks were usually

rushed in at the last moment, and sometimes the lights too, and there was no opportunity to go along the desks when they were actually arranged and mark out the positions for the lights; the lighting points had to be decided a very long time beforehand in such positions as could be judged were the most suitable from the information to be gathered from the officials who were interested in the matter, but as previously stated, the difficulty lay in finding the best positions in a room that was to be used for different purposes, some of which purposes were only indefinitely contemplated prior to the opening of the school. It should always be borne in mind that the pupils are not allowed to select a well-lighted place in the room; they occupy fixed places, and the light must be arranged to reach them.

Mr. P. J. Waldram, F.S.I., said that as an architect, and as one who had been endeavouring to study the subject of daylight for some years, he desired to tender Dr. Kerr his personal thanks. As Dr. Kerr pointed out, quantitative measurements of the small proportion of daylight enjoyed by interiors was absolutely useless. It varied from month to month, from day to day, and from hour to hour by several hundreds per cent. without materially affecting the usefulness of the light. It might vary in a class-room between 9 a.m. and 3 p.m. by 300 per cent. without affecting the convenience of those using the light, and in fact without their being conscious of anything but a nice comfortable light the whole time. The human eye had been taught by countless ages of outdoor experience to reduce all excess of daylight illumination down to a moderate level, and it only complained when it was subjected to a glare or when it was called upon to work under those conditions of insufficient light which to our prehistoric ancestors heralded the period of darkness when work had to cease. In addition to the diurnal and seasonal variations, daylight also varied curiously according to the state of the sky—a snowy day in December might be brighter than a wet day in June; slightly cloudy sky gave much more light than clear blue sky, &c. Any attempt, therefore, to measure the daylight of interiors by measurements of the light at any period, would be like trying to value the good will of a retail business by counting the number of customers in the shop at a particular moment. The measurements of projected sky area described in the paper are equally untrustworthy. He had measured many rooms, from every part of which an ample sky area was visible, which enjoyed a splendid aspect but a wretched illumination, and which required artificial light on the slightest provocation. On the other hand, there were rooms (like some of the Law Courts) in which practically no sky was visible, but which enjoyed a good light almost up to sunset on a dull day. This was because the diffused light was reflected from the paper at a high angle; light striking the paper at a low angle did not enter the eye at all. The light of a class-room could be tested roughly by ascertaining whether at, say about an hour after sunrise and half-an-hour before sunset on a clear day a good reading light was enjoyed at the worst desk. This was the only test possible to the unaided human eye, and it had serious disadvantages. In the first place, one must either wait for a clear day and be at the class-room exactly at the right time or else make a proper allowance for the elevation of the sun and the state of the sky, and the accurate determination of this latter correction demanded a high degree of skill and experience. Photometrically, however, the daylight illumination of every desk could be rapidly ascertained by comparing it with the illumination of a small portion of the zenith sky. This could be effected by reducing the illumination falling upon a Trotter photometer by means of a 10-in. tube having an aperture which was a certain proportion of the area of a 10-in. hemisphere. This method of measurement originally devised by Mr. Trotter was extremely simple, easy and speedy. One could measure every desk in quite a large school in an hour or so at almost any time of the day or the year, because

the *proportion* of light enjoyed by any interior was constant over all ranges of outside variation. It had recently been recommended in the annual report of H.M. Chief Inspector of Factories for determining the sufficiency of the lighting of underground workshops. The illumination enjoyed by a desk depended upon a large number of factors, such as the state of walls, ceilings and glass, the height of window heads, and especially the angle at which the light came. These factors were all allowed for in such a proper *relative* quantitative test, and if a number of schools known to be good, bad, or indifferent, could be systematically tabulated, it should not be difficult to arrive at a certain minimum standard for the worst desks in the room. Personally, he would be inclined to place that standard at about one-thousandth of the outside illumination measured from the zenith sky at a time when the sun was not either shining directly into, nor was being directly reflected into the class-room. It was most essential that the illumination on the desk should be measured on a surface placed on the actual working slope, and it *must* be viewed from the natural angle for reading and writing, because a desk and its paper or book might receive quite a large amount of low angle light, but that merely illuminated the scholar's chest; it did not reach the eye naturally, and was a direct temptation to a cramped position. So vitally important was the question of high angle light that he would be inclined to sacrifice a great deal in order to illuminate class-rooms by top lights, and suggested that lantern lights with flat ceiling lights would overcome many of the difficulties. When top lights were impossible, as in the ground floor of two-story buildings, he would prefer to raise the sill level and to increase the area of the upper portions of the window until the window walls were practically a glazed frieze, broken only by the minimum amount of brick piers required to support the wall and floor above.

MR. K. EDGCUMBE (Messrs. Everett, Edgcumbe & Co.) expressed great interest in the Wingen Photometer, described by the author, as this instrument was very similar in principle to one developed by him (the "Luxometer"), and which he exhibited to the meeting. In this, the standard took the form of an electric lamp, worked off a small unspillable accumulator, instead of a flame lamp.

He considered that the electric standard had many advantages over the latter, which necessarily took a long time to settle down, and there was the added difficulty that it was necessary to turn the flame up and down in order to obtain a balance of illumination. This would upset the candle-power for some considerable time, besides which it was a very difficult matter to read the height of the flame, in fact, he thought it would be impossible to do so with a greater accuracy than 10 per cent. or even 20 per cent.

The "Luxometer," in addition to having an electric standard, was made with an adjustable screen worked by a milled head on the Trotter principle.

The "test plate" could be removed from the instrument and laid upon a table or elsewhere, and, after viewing it through the eye-piece, the illumination was read off the dial in foot-candles. Measurements of intrinsic brilliancy could also be made, besides which the instrument had a "daylight attachment" for the measurement of window efficiency, as suggested by Mr. Percy Waldram.

MR. E. S. MORTIMER, who said he heartily welcomed the advent of the illuminating engineer in connection with school lighting, mentioned an instance in which an engineer had placed all the heating apparatus in certain class-rooms immediately under the windows. In consequence, when the windows were open for ventilating purposes, most of the heat was lost. Moreover, the clouding of the windows, owing to the moisture and dust deposited upon them, seriously curtailed the amount of light that should enter the room. The school doctor might possibly insist on the more frequent cleaning of windows. The assistance of the real lighting expert

and the school doctor was welcomed by teachers to counteract the faults of partial experts.

Dr. H. R. B. Hickman had tried the Wingen photometer for estimating the daylight illumination in various parts of a class-room. He divided the room into squares and proceeded to compare the daylight falling on each square with the light of the standard lamp. He found it impossible to get more than a few of the areas measured before the quantity of daylight altered, and thus comparisons between the areas marked out became quite fallacious. No doubt this instrument was useful for testing a steady artificial illumination.

With regard to the position of windows or of artificial light in relation to the desks, one speaker did not appear to realize why a light from the left-hand side was preferable. He (Dr. Hickman) had always understood there were two very good reasons; one was that the shadow of the pen or pencil should be cast away from the words being written, *i.e.*, "the hand should not be in its own light"; and the other was that any regular reflection from the paper should not enter the eye and produce a dazzling effect. When electric lighting was first introduced the lights were often placed high up for effect. This was apparently good for the general illumination of a room, but reading—especially from glazed paper—was found to be very trying, owing to the direct reflection of the source of light from the paper. The light should be so placed that regular reflection from a book or blackboard took place in a direction anywhere but towards the eyes, for it was by the irregularly reflected or diffused light alone that objects were rendered visible. That the regularly reflected light should fall on to the chest rather than into the eyes, was surely most desirable.

Mr. P. Abbott spoke as a technical teacher, not in a London County Council school. He said that he seemed to have experienced nearly every one of the faults mentioned during the discussion, and the Society would earn the gratitude of technical teachers who did all their work by artificial light if it would turn its attention to the peculiar conditions under which they laboured. Blackboard glare was a very serious matter, for there was always a percentage of the students who could not see anything on the blackboard due to this cause. For some years the only light in the room in which he was working was a big central light containing four upright incandescent gas burners, which gave very big shadows under the light; there was a poor light in the corners of the room, and many of the students in the class would see very little of the blackboard on account of the glare. There were also one or two fish-tail burners over the blackboard, and there was some doubt as to the cause of the glare. By arranging brown paper screens over the central light, the glare on the blackboard completely disappeared. He suggested that it might be possible to improve the lighting of blackboards by the use of tubolite along the tops, provided the light was properly shaded from the students.

Mr. J. Darch (*communicated*): I have recently examined several modern Board Schools, and found that while there was much that was excellent in the daylight conditions, the artificial illumination was almost invariably unsatisfactory. The chief defects were:—

(1) Insufficient illumination.

(2) Want of uniformity. Generally speaking there were but four lights for a class of forty children, and these were placed too near the centre of the room, forming undesirable shadows at some of the desks.

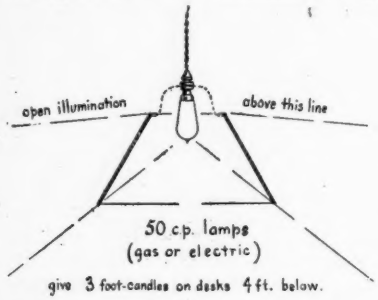
(3) In almost every case the glow-lamp or mantle was exposed in the direct range of vision, thus interfering with the children's view of the blackboard. This was one of the most irritating and serious of the defects, and the most prevalent. Teachers also complained of the dazzling effect of such lights—placed at a height of 7 ft. from the floor, *i.e.*, almost on the eye level.

(4) Frequently the more or less glossy surface of the blackboard reflected the light directly into the children's eyes.

(5) Insufficient use is made of the good reflecting powers of the white ceilings with which most classrooms are provided; reflectors are used above the lamps which darken the ceiling and tend to throw the light down on the desks in concentrated spots.

To remedy these defects, I suggest three alternative methods, either of which may be made satisfactory.

(A) Indirect lighting by means of inverted arcs or a corresponding arrangement of incandescent gas



mantles: downward reflectors should not be used, and the lamps—or their covers or shades—should hang sufficiently low to uniformly illuminate the ceilings and upper walls.

(B) Direct lighting from high placed ceiling lights suspended about 2 ft. from the ceiling, so that the latter may be well illuminated: the lamps should not be placed centrally, but towards the left-hand window and rather to the rear.

(C) Low placed pendants are satisfactory if used in sufficient number (say 10 or 12 where there are now 4 or 6), and properly shaded. The shades should be opaque and in the form of a deep cone with a large open top, as sketch; the depth of the side of which should be adjusted to illuminate as much as possible of the ceiling and walls; at the same time be just enough to protect the eyes of both teacher and scholar. This arrangement would give all the necessary light on the desks, while the ceiling and walls would shed a soft light over the room and no lights would be visible.

In all three methods a minimum illumination of 3 foot-candles should be provided on the desks.

The wall at the teachers' end, facing the children, is really an exhibition screen; it is comparable to the stage of a theatre, and as such its lighting should be separately considered. A stronger light is required here than on the desks; these lights should be capable of an illumination of 5 or 6 foot-candles, each well enclosed by an opaque screen and disposed along in front of the exhibits so as to avoid gloss, and so that they may be severally turned on as may be required.

I have dealt only with the lighting of the most important room — the classroom; but I found that the lighting of many of the art and other special classrooms and of the halls were equally in need of reform.

Some Publications Received.

International Magazine of School Hygiene.—This issue of the organ of the International Congress contains, among other interesting items, an article by Dr. Max Oker-Blom on Comparative Measurements of Light and Shade under Different Artificial Light in the Primary Schools of Helsingfors (Finland). An exhaustive series of tests are recorded both with direct and indirect illumination, and special attention is given to the question of the shadow of the hand whilst writing. In this locality the question of artificial lighting in schools is of special consequence, owing to the long winter nights and diminution in intensity of daylight during a large portion of the year.

Public Libraries.—A magazine devoted to the improvement of American libraries by discussion of the problems of library work.

The Library World (February, 1911).—A monthly record of progress in the development of Public Libraries. We note in this issue a brief reference to the discussion on Library Lighting which took place at the meetings of the Illuminating Engineering Society in January last.

Notes on the Illumination in Various London Schools and Colleges.

By Leon Gaster and J. S. Dow.

(Presented at the adjourned discussion of the Illuminating Engineering Society on School Lighting, held at the House of the Royal Society of Arts, London, on March 14th.)

It occurred to the writers that it would be interesting to supplement the valuable papers by Dr. James Kerr and Dr. Bishop Harman by a few tests showing the actual conditions of illumination prevailing in various London schools and colleges.

With this end in view, a few schools attended by children and infants, some of the large public schools for boys, and a series of colleges were visited. It was naturally impossible to do more on this occasion than select a few typical examples of each class, and the results of these casual visits made are not to be regarded in the light of a comprehensive examination or report. A truly searching investigation into the lighting conditions in any one college or school would alone furnish ample material for an evening's discussion. It is hoped, however, that the results will be of service in showing the usual arrangements for lighting at present employed, and the average existing order of illumination. They should also serve to show how comparatively simple measurements of illumination have now become.

We hope that others will be sufficiently interested to follow up the suggestions tentatively thrown out, to make measurements in the particular schools or colleges under their supervision, and to devise improved methods of lighting. It would be to the interest of school and college authorities to encourage investigations of this description, as it would doubtless often be possible, by comparatively small modifications, to secure substantial improvements. Work in this direction is certainly needed. The question as to what constitutes ideal illumination in educational institutions of different kinds still remains to be settled, but there are already evident many directions in which improvements are possible and desirable.

The data collected refer mainly to artificial illumination; there are, however, also a few measurements of daylight which may be of interest. The results as regards artificial light are summarized in Tables I., II., III., IV., and V.; daylight is treated in a special section.

Nature of Tests and Observations.

In each case the chief object was to make measurements of the illumination on desks and blackboard. In addition an approximate estimate was made of the consumption of gas and electricity, as far as local conditions and information available allowed. All measurements of illumination were made with the Holophane Lumeter instrument.

Elementary and other London Schools.

In this class, schools at Haverstock Hill, Charing Cross Road, Richard Street, Islington, and Merton Road, Wandsworth, were visited. The two former are electrically lighted and the latter by gas. It appears that the conditions at Haverstock Hill (Fig. 1) are typical of the new electric installations. It will be seen that the artificial illumination on the desks is very uniformly distributed; in this respect it presents a marked contrast with the daylight illumination. The opal shades are specially designed for the size of the classroom. They cover the half-frosted tungsten lamps in such a way that one is not able to see the naked filament of the lamp even from the back desks; and the blackboard illumination, over 3 foot-candles, is also above the average.

A great simplicity is effected by the adoption of a standard size of class-room and the choice of the system of lighting best adapted to the conditions. The watts per square foot, about 0·5, would probably be considered satisfactory in view of the illumination secured, and the wiring arrangements have also been devised with a view to the greatest possible simplicity and economy in first cost.

distribution of illumination in the various rooms visited is less satisfactory than at Haverstock Hill. For example in the plan of the cookery and laundry rooms, shown in Fig. 2, several defects may be noted. In the former case the illumination of the demonstration table is too weak, and on the dresser even more so; in the latter the arrangement of the lamps tends to throw too much light on the

TABLE 1.—ILLUMINATION DATA OF L.C.C. SCHOOLS.

School.	Nature of Lighting.	Cub. ft. per hour.	Cub. ft. per hour per sq. ft.	Illumination (foot-candles).		
				Demonstration Table.	Desks.	Blackboard.
	Gas.	Estimated.		Measured		
RIVERSDALE, SOUTHFIELDS						
Class room (infants)	4 incandescent burners Kern No. 4, with opal globes and reflectors	16	0·040	3·5	4·5-5·0	1·7-2·0
Assembly Hall	6 twin incandescent burners, Kern	48	·033	3·2	2·4-3·6	—
RICHARD ST. ISLINGTON						
Class room (1)	4 upright incandescent burners, with opal shades		0·04	—	1·8-4·5	0·8-2·0
„ „ (2)	4 twin upright incandescent burners unshaded		0·08	—	2·2-3·0	3·5-3·9
Large room, used for needlework, &c.	10 twin upright incandescent burners		0·04	—	2.5-3·0	2·3
	Electric.	Consumption in watts.	Total watts per sq. ft.			
HAVERSTOCK HILL						
Typical class room	Tungsten (opal shades)	220	0·5	—	2·0-2·5	3·5
CHARING CROSS ROAD						
Class room	Carbon (with opal shades)	660	1·2	2·5	1·6-3·0	1·2-2·5
Cookery room	„ „ „	420	1·1	0·75-1·6 (Dresser 0·1-0·2)	1·7-2·5	0·8
Laundry room	„ „ „	480	1·2	1·8-2·8 (Sink and Mangle, 0·4)	0·9-1·8	0·5

The lighting of the schools in Charing Cross Road is of older date. Carbon filament lamps are still used, and it will be observed that the consumption per square foot is high. Nevertheless the

gangways, while the illumination in the neighbourhood of the sink and mangle in the corner is only about half a foot-candle. In some cases the naked filament of the lamps are only

imperfectly concealed from the eye by the shades used. In a third room, devoted to ordinary classwork, this was particularly noticeable from the back row.

By the kindness of Mr. Chalmers, manager of the school at Richard

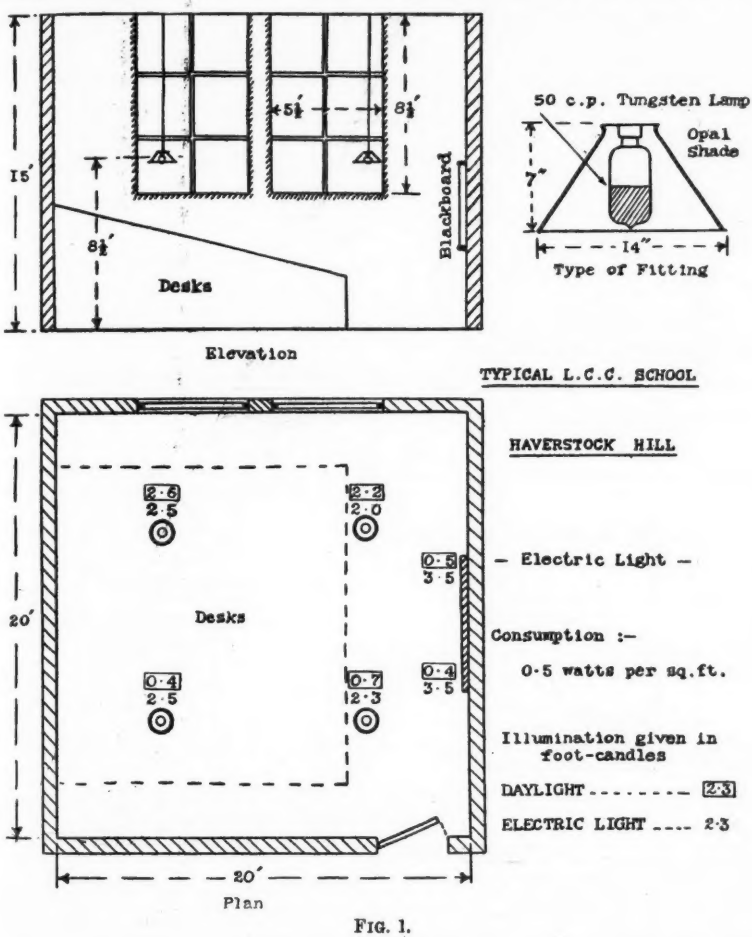
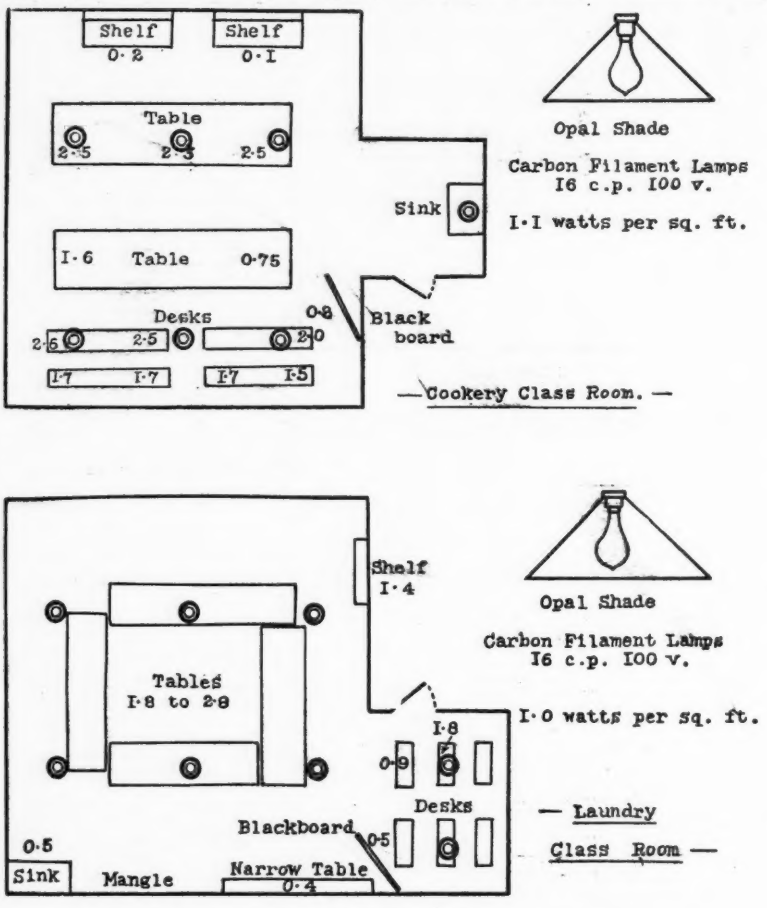


FIG. 1.

Street, Islington (lighted by gas), one of the authors had an opportunity of visiting these schools. It is interesting to observe that the distribution of illumination in many of the classrooms resembles very closely that at Haverstock Hill. A large number of rooms were visited, and the value of the illumination on the desks repeated itself very consistently. One would be inclined to suggest that the shades used might be exchanged for some form (such as that described by Dr. Harman) in which the mantle is completely screened from the eye; in several cases those at the back of the room could hardly avoid being dazzled by the indirect view of the mantles when looking towards the blackboard. In several classrooms complaint was made of the light, and yet the intensity of illumination proved on measurement to be up to the standard

maintained in the others. It appeared, however, that in each of these cases work especially exacting to the eyes, such as sewing, shorthand, or reading music, was carried on. It may be suggested that in such cases a higher standard of illumination is desirable, and also that special pains should be taken to exclude anything in the nature of glare. In many cases the increase in illumination might probably have been secured by throwing downwards some of the light which at present escaped and illuminated the walls. On the other hand, it must be recalled that rooms are often used for quite distinct purposes at different times, and must be lighted accordingly. For example, a hall may be used for a large sewing class on one night and for drilling on another. Perhaps the most severe task of all for the eyes, owing to the lack of contrast between the material and cotton, is sewing dark cloth with black thread.



CHARING CROSS ROAD SCHOOLS — Electric Light.

FIG. 2.

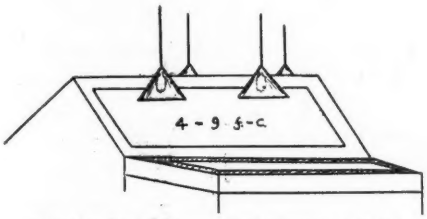
Another gas-lighted school visited was

that in Merton Road. This was mentioned to us as being a new installation. The standard of illumination proved to be well above the average, namely, 4½ foot-candles on the desks; the blackboard lighting, however (1·7–2 foot-candles) was somewhat low, as a consequence of the opal shades used. The shades have the merit of almost completely covering the mantle, so that it is not likely to be seen by the scholars.

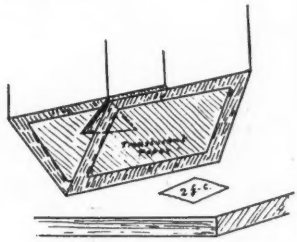
ART SCHOOLS, TRADE SCHOOLS, &c.

An excellent illustration of the recognition of the need for higher illumination in the case of special work is furnished by the Arts and Crafts School (Southampton Row). In the accompanying illustration the illumination in the various rooms devoted to wood-carving, book-binding, &c., is tabulated: it is of quite a different order from that met with in elementary schools. Some special devices for the lighting of a compositor's frame, jewellery work, and etching, are also shown. It is interesting to note that green light seems to be preferred for fine jewellery work. It may be added that throughout this building no case was met with in which the actual source was exposed to the eye, and the illumination, besides being high, was singularly free from glare.

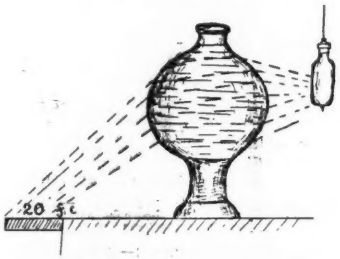
In the Trade School for Girls (Bloomsbury) inverted arc-lighting is employed, as it also is very extensively in the Arts and Crafts School. In other rooms where machine work is done local drop-lights are used. The local illumination here is again high, from 4 to 8 foot-candles.



Illumination of Compositor's Frame: shaded lamps on left of workers.



Etching Table: very diffused illumination desired.



Jeweller's Work: use of special water-lens coloured green.

SOME SPECIAL USES OF ILLUMINATION AT THE ARTS AND CRAFTS SCHOOL
(Southampton Row, London).

Nature of Work.	Style of Lighting.	Illumination (Foot candles).
Wood carving room.	Local Pendants Shaded Lamps	30
Architecture ,,	Inverted Arcs	7
Silversmith's ,,	,,	4·5
Art ,,	,,	6·5
Bookbinding ,,	,,	8·0

FIG. 3.

PUBLIC SCHOOLS FOR BOYS.

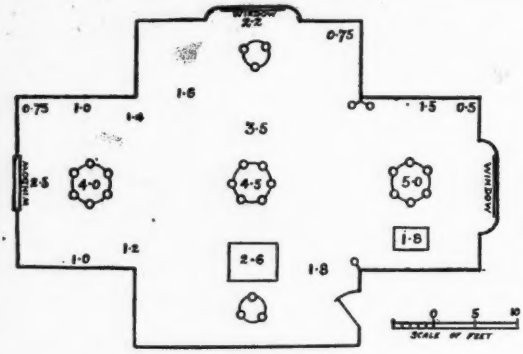
It was also thought of interest to secure permission to take measurements in the classrooms of a few of the larger public schools, and this was done in the case of Harrow, Dulwich College, St. Paul's, and the City of London School.

It should again be emphasized that these few data do not constitute anything in the nature of a report on the lighting in the schools visited; it would

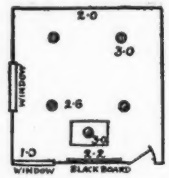
clearly be out of the question to attempt anything in this direction without much more exhaustive investigation. All that has been done is to make measurements in a few typical classrooms in each case.

The arrangement of the lights in some of the classrooms at Harrow is shown in Fig. 4. The big hall is lighted by several chandeliers carrying opal shades and frosted tungsten lamps. We understand that the hall is only very occasionally used by artificial light. The lamps are high up, but the distribution of illumination is not very even. Immediately below the chandeliers it is as high as 5 foot-candles, but on some of the back desks only 0·5; however, it was stated that the desks in these extreme positions are not *often* occupied. In the classrooms opal shades and frosted tungsten lamps are used throughout; the average illumination is of the order of 2 to 2·5 foot-candles, but the remote desks sometimes received slightly over a foot-candle. In summer no artificial light is required; in winter work goes on until 6.45 P.M. three days a week.

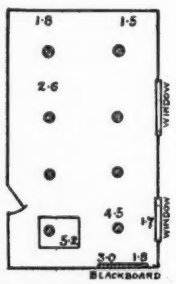
Dulwich College is interesting because the older part of the buildings is lighted by gas and the newer science buildings by electricity. The big hall, where assemblies take place and evening preparation is also done, is lighted by two rows of twin incandescent burners down the sides of the hall. The mantles are completely covered in by opal globes, and this, while giving a soft and diffused light, also absorbs a good deal. The result is that mid-way between the lamps there is only about 0·6 to 0·7 foot-candles, much less than that met with in the elementary schools visited. In the classrooms inverted opal bowls covering twin incandescent burners are used, the light being partly transmitted and partly thrown down by the white ceiling. From the standpoint of absence of glare the method has much to recommend it, but the illumination is weak, being under 0·75 foot-candles in the case of some of the more remote desks, and the blackboard illumination is also low. It may be added that until two years ago, we were informed, the



Large Hall.
Approx. watts per sq. ft. :—0·5
Approx. window space per sq. ft. of floor area :—0·15



Head Master's Classroom.
Watts per sq. ft. :—0·5
Window space per sq. ft. of floor area :—0·15



Mathematics Classroom.
Watts per sq. ft. :—0·45
Window space per sq. ft. of floor area :—0·09

FIG. 4.—ARTIFICIAL ILLUMINATION AT HARROW SCHOOL.

lighting was all by flat-flame burners.

Carbon filament clear-bulb lamps (8 c.-p., 205 volts) are used in the electrically lighted rooms; they are hung in a cluster without any form of shade (see Fig. 7), and, in the position shown, are in the direct line of vision from the back desks to the blackboard; the position is also clearly disadvantageous as regards distribution of light, and inclined to throw head shadows. It is not surprising to find that the back desks receive only 0·4–0·6 foot-candles (see Fig. 5).

(The school library is lighted in a rather interesting manner, by inverted electric incandescent lamp fixtures: it was, however, undergoing alterations on the occasion of our visit, so that no tests could be made.)

In St. Paul's School the lighting is by electricity. The assembly hall is illuminated by rows of 110 volt tungsten lamps high up on the battens. This high position is again favourable to reducing the effect of glare, but it leads to a somewhat low illumination over the hall, only 0·7 to 0·8 foot-candles (Fig. 6). This room is used for assembly, but only occasionally for classes. In the classrooms the order of illumination was about 2·5 foot-candles over the desks; clear bulb lamps with ordinary opal shades were used.

In the City of London School artificial lighting is of minor importance, as

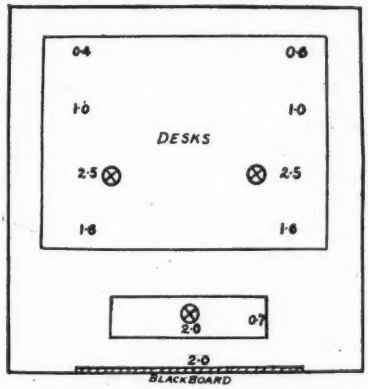
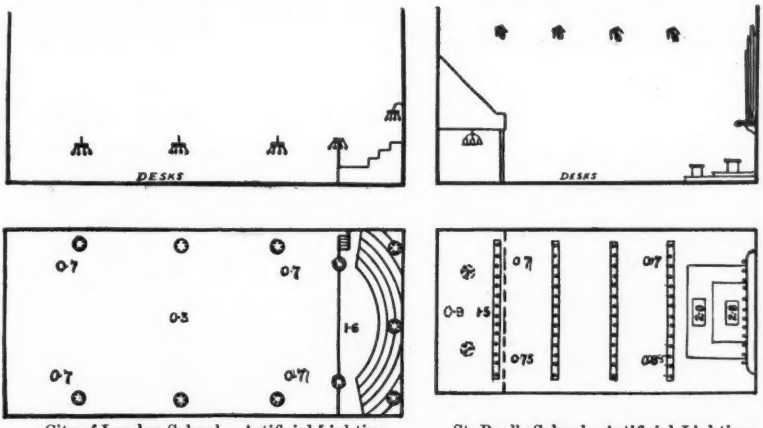


FIG. 5.—Dulwich College Physics Lecture Theatre (Science Section).

work ends at 3 P.M. The Assembly Hall is in this case never used for class-work; the artificial illumination over the hall is, indeed, too weak for it to be conveniently used for this purpose. The centre of the room is so far from the side brackets that it only receives about 0·3 foot-candles. On special occasions, it was stated, the gas "suns" near the roof, with flat-flame burners, are also lighted, but this is only rarely done (see Fig. 6).



City of London School.—Artificial Lighting of Hall by side brackets, with weak centre illumination.

St. Paul's School—Artificial Lighting of Hall by battens in the roof.

FIG 6.

In the classrooms the illumination was also low, in some cases only 0·4–0·7 foot-candles, but, as stated above, artificial light is not much used. Clear bulb carbon filament lamps (200 volts), with ordinary opal shades, are used.

TABLE II.—ILLUMINATION DATA OF PUBLIC SCHOOLS.

School.	Nature of Lighting.	Consumption in Watts.	Total Watts per square feet.	Illumination (foot-candles).		
				Tables.	Desks.	Black-board
HARROW		Estimated		Measured		
Headmaster's class room	Tungsten (frosted)	125	0·5	3·0	2·0-3·0 1·0 in corner.	2·2
Mathematics class room	" "	250	0·45	5·2	1·5-4·5	1·8-3·0
Mathematics class room	" "	220	0·5	2·2 1·0 in shadow.	1·6-4·4	1·4-8·0
Exam. Hall	" "	750	0·5	1·8, 2·6	0·5-5·0	1·6
ST. PAUL'S						
Class room	Tungsten (opal shades)	245	0·49	5·3	2·4-2·8	2·8
	Carbon (" ")	120				
Assembly Hall	Tungsten (on battens 35 ft. above floor)	2590	0·81	2·0-2·8	0·7-0·8 0·9 under gallery.	—
CITY OF LONDON						
Class room	Carbon (opal shades)	300	0·62	1·6	0·4-0·7	0·7-0·9
Assembly Hall	Tungsten	2110	0·47	1·6 on platform.	0·3-0·7	
DULWICH (Science Blgs)						
Physics Lecture Room	Carbon	450	0·6	72·0	0·4-1·6	2·0
Chemical Laboratory.	"	600	0·8	2·0	1·1-1·6	—
	Gas.	Cub. ft. per hr.	Cub. ft. per hr. per sq. ft.			
DULWICH						
Preparation room	Incandescent, upright mantles, opal globes.	96	0·035	—	0·6-0·8	—
Class room (1)	Incandescent, semi-inverted, opal bowls.	14	0·045	—	1·1-1·5	—
" (2)	" " "	28	0·045	1·0	0·75-2·0	0·7

(To be continued.)

A Coming Book on Illumination.

AT the present time there is a great need for up-to-date information on illuminating engineering, and a book summarizing, in a popular and yet comprehensive manner, the most recent developments, and also containing references to the most important recent literature on the subject, should be of service.

We understand that a work on these lines entitled 'Modern Illuminants and the Principles of Illuminating Engineering' is in course of preparation by Messrs. Leon Gaster and J. S. Dow, and will be issued by the well-known publishers, Messrs. Whittaker & Co. (London).

School Lighting.

(Proceedings at a meeting of the Illuminating Engineering Society held in the House of the Royal Society of Arts (London), on Tuesday, March 14th, 1911.)

A MEETING of the Society was held on March 14th, Mr. Chas. W. Hastings occupying the chair in the unavoidable absence of the President.

The minutes of the last meeting having been read and confirmed, the chairman called upon the Hon. Secretary to read the names of applicants for membership received since the last meeting, which appear in the subjoined list.

Before the discussion on 'School Lighting' was resumed, the Chairman invited Dr. Bishop Harman, who had been prevented by indisposition from attending the previous meeting, to give a demonstration of his apparatus for testing fatigue of the eye based on measuring the extent to which binocular vision was diminished.

MR. L. GASTER and MR. J. S. DOW were then asked to summarize briefly the results of the tests of illumination carried out in a number of public schools, L.C.C. schools, and technical colleges, and MR. T. E. RITCHIE and MR. J. G. CLARK showed slides illustrating the lighting of certain schools by inverted arc lighting and incandescent gas lighting respectively.

In the discussion which followed MR. F. W. GOODENOUGH, DR. PISANI, DR. E. H. NASH, MR. RYAN TENISON, MR. J. DARCH, MR. J. ECK, and MR. V. H. MACKINNEY took part.

Communications were read from MR. R. J. WALLIS-JONES, and MR. SHERARD COWPER-COLES, and DR. J. KERR and DR. N. BISHOP HARMAN briefly replied to some of the points raised in the discussion.

The Chairman then proposed a hearty vote of thanks to the two gentlemen who had so ably introduced the subject of the discussion, and the members subsequently adjourned to the Library, where tea and coffee were served.

NEW MEMBERS OF THE SOCIETY.

THE names of the following applicants for membership have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on March 14th :—

Members.

Davies, A. J. Devereux ..	H.M. Asst.-Inspector of Factories, 29, Wordsworth Avenue, CARDIFF.
Driver, F. P...	Works Manager, Osram Lamp Works, Brook Green, Hammersmith, LONDON.
Fisher, W. Clark	Engineering Dept., Holophane, Ltd., 12, Carteret Street, Westminster, LONDON, S.W.
Green, W.	55, Gordon Gardens, West Hampstead, N.W.
Foulds, M.	Manager, Westinghouse Cooper-Hewitt Co., 36, Royal Crescent, LONDON, W.
Howgrave-Graham, R. P. ..	Demonstrator in Electrotechnics at Finsbury Technical College, 21, Worsley Road, West Hampstead, LONDON, N.W.
Lock, H. C.	Electrical Engineer, 55, Rutland Park Mansions, Willesden Green, LONDON, N.W.
Marryat, H.	Electrical Engineer, Hon. Treasurer of Electrical Contractors' Association, 28, Hatton Garden, LONDON, E.C.
Talbot, H.	Chief Outdoor Lighting Inspector to the South Metropolitan Gas Co., Old Kent Road, LONDON, S.E.

Corresponding Members.

Basset-Jones, W., JUN. ..	Lighting Engineer, 1, Madison Avenue, NEW YORK.
Oker-Blom, DR. W.	University of Helsingfors, FINLAND.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

Official Notices.

Date of Next Meeting.

THE next meeting of the Illuminating Engineering Society will take place at the House of the Royal Society of Arts (John Street, Adelphi, London) on **Monday, April 24th**, at 8 P.M., when two papers will be presented by MR. HAYDN T. HARRISON, M.I.E.E., and MR. P. J. WALDRAM, F.S.I. The Chair will be taken by THE PRESIDENT, PROF. S. P. THOMPSON, D.Sc., F.R.S.

The following is a synopsis of these two papers, which, it is hoped, will be of service to those desiring to join in the discussion :—

The Ratio of Light to Illumination.

By HAYDN T. HARRISON, M.I.E.E.

SYNOPSIS.

By light is meant source of illumination. The confusion which often arises by taking light as illumination.

Precautions to be taken when measuring the candle-power of a lamp. Ditto, when measuring illumination, and the laws on which such measurements are based.

Useful definition of light values from the point of view of illuminating engineers compared with the usual trade descriptions.

Suggested division of light values into definite classes, and the effect of varying same by means of reflectors or globes.

Reflecting value of surroundings compared with brilliancy as measured by a lumeter.

General illumination *versus* special illumination. Effect of great variation in degree of illumination. Shadows and their uses.

Some Notes on the Effect of Wall-papers upon the Illumination of Interiors.

By P. J. WALDRAM, F.S.I.

SYNOPSIS.

The results required of an illuminant in ordinary rooms. Measurements in the working plane only insufficient. Value of bright walls, physically, commercially, and as illuminants.

Reflection, co-efficients, and surface brightness. Suggested specification of wall brightness. The necessity for means of predetermining working plane illumination and wall brightness from c.p. curves. Device for obtaining c.p. curves of lamps and shades in use.

Tests of table plane illumination and of wall brightness in rooms of different sizes with lamps at different heights in the presence of wall papers of different colours.

Several rules deduced from tests. Comparison of rules with various examples of illumination. The necessity for further detailed investigation.

Members desiring to join in the discussion are requested to send in their names beforehand to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.), to whom applications for tickets should also be addressed.

Date of Annual General Meeting.

The **Annual General Meeting** of the Society will take place on **Tuesday, May 9th,** at 8 P.M., at the House of the Royal Society of Arts (John Street, Adelphi, London, W.), when the Report of the Council for the past session will be presented.

It is hoped that all members will make a special effort to be present.

School Lighting (*continued from p.* 208).

[Discussion resumed at a meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, on March 16th, 1911].

DR. N. BISHOP HARMAN: Your Hon. Secretary has asked me to give some account of an instrument recently devised by me for measuring the desire for binocular vision and its variations. The instrument is called the "Diaphragm Test."* Briefly, use is made of a phenomenon which doubtless many of you have observed. On looking out of a window a man with two effective eyes sees more widely than does a man with one eye, for the two eyes from their slightly different positions look round the sides of the window. In the instrument there is a small window in a screen: it is so arranged that, looking at a test card fixed on the mark behind the screen a certain width of the middle of the card is seen by both eyes, and the major portion—the right and left wings of the card—is seen by the left and right eye. The general nature of the apparatus is shown in Fig. 1. Fig. 2 shows the lines of vision, and Fig. 3 the various parts of the cards as they are exposed to the eyes.

FIG. 1.—General Nature of Diaphragm Testing Device.

The capability of reading the test fluently depends upon that middle band exposed to the two eyes; it is the "oculopoise," the eye-brain balancing mechanism steady the eyes upon it, just as the body-balancing mechanism keeps a man balanced on a tight rope or plank.

In the instrument the width of the window is variable, so that the oculopoise can be varied and the narrowest balance required for any individual measured.

Now the capacity for binocular vision varies in each individual according to his condition. The double vision, *i.e.*, failure of binocular vision, incident to alcoholic excess, is the subject of many jokes; we frequently see it from the toxic effect of fevers. The same, only less in degree, occurs in fatigue, which is also caused by the production

* This instrument was previously described in *The Illuminating Engineer* (Lond.), vol. iii., 1910, p. 559.

of toxic substances, and by this instrument the effects of this fatigue can be measured in the variation it causes in the working of one of the most highly-developed and delicately-balanced of automatic physical phenomena.

At present observations on fatigue in school children are being made, and it is hoped the test may prove of value in determining the effects of various conditions of illumination.

It should be added that the test is not one to be placed in the hands of all and sundry, for its successful usage requires a certain knowledge of eye-work, not for the actual use of the instrument, but for the necessary preliminary examination of the subject's eyes.

Full details of the instrument can be obtained from Messrs. Culver, White Lion Street, London.

THE CHAIRMAN then asked Mr. Gaster and Mr. Dow to give a brief account of the tests of illumination which they had carried out in various schools and colleges.

(These results, with tables and diagrams, will be found on page 209.)

MR. THOMAS E. RITCHIE.—I should like to make reference to several of the points which have been raised in the papers and in the discussion which has followed them, and also to submit for your inspection a few slides showing the artificial illumination of various rooms in two local educational institutions, which, I hope, may be of interest.

Referring to Dr. Bishop Harman's paper, I notice with regret the exceedingly low minimum illumination of 1 foot-candle to which he makes reference and apparently sanctions. I consider that a minimum illumination of anything like this order is totally inadequate, even for elementary schools, if for no other reason than that many would object to providing more light than a minimum having so responsible a sponsor and the fact that it is not possible within such a limit to allow any margin for the wide variation in the light required by different children to carry on precisely the same work. That such variation does occur in practice is to a considerable extent proved by a test in which I was interested, and which was made some eighteen months ago at a school in the north of England. The room in which the tests were made was

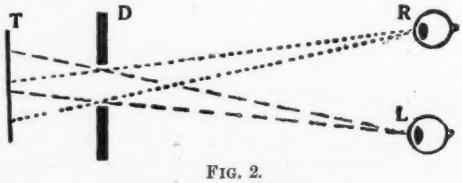


FIG. 2.
Diaphragm Test (Dr. Harman).

one used for Dress-Making and Needlework (subjects which are largely taught in elementary schools and especially at evening classes, in which the work must of necessity be carried on by artificial light).

The room was lofty, 16 ft. to the ceiling, well lighted with a good north light, decorated in a light cream to within 3 ft. of the floor level, below which the walls were of a dark chocolate colour, and provided with six large windows, each fitted with an opaque dark blue blind. The tests were made in June between, for the daylight tests, 11 A.M. and 3.30 P.M., and for the artificial light tests 7.45 P.M. and 9.0 P.M. The materials used were natural coloured Shantung Silk and Sewing Silk to match. Ten girls were tested, ranging in age from 16 to 22 years. The eyes of each had previously been examined by a qualified oculist and pronounced normal. The procedure adopted was to allow each girl (the individuals were tested separately) to seat herself in a position distant about

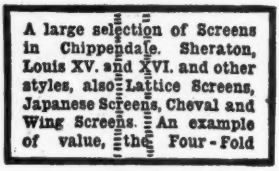

A large selection of Screens in Chippendale, Sheraton, Louis XV. and XVI. and other styles, also Lattice Screens, Japanese Screens, Cheval and Wing Screens. An example of value, the Four-Fold

FIG 3.
Test Card (Dr. Harman).

16 ft. from the windows, in which the light was received upon the work-table from the top left-hand corner.

The blinds were then simultaneously and very gradually lowered by an

attendant stationed at each window at intervals sufficiently great to allow of the eye accommodating itself to the diminished illumination until the worker could only just manage to see comfortably. The illumination upon the work-table was then measured, and was found to vary between a minimum of 16·4 and a maximum of 38·7 foot-candles.

In the tests made by artificial light, the blinds were carefully drawn to exclude any remnants of twilight. The illumination was provided by metallic filament incandescent lamps attached to adjustable pendants, and the light was varied by gradually raising the lamps at intervals of three minutes. The illumination necessary varied from 7·2 foot-candles as a minimum to 12·64 foot-candles as a maximum, both sets of measurements being made by the same "Weber" photometer.

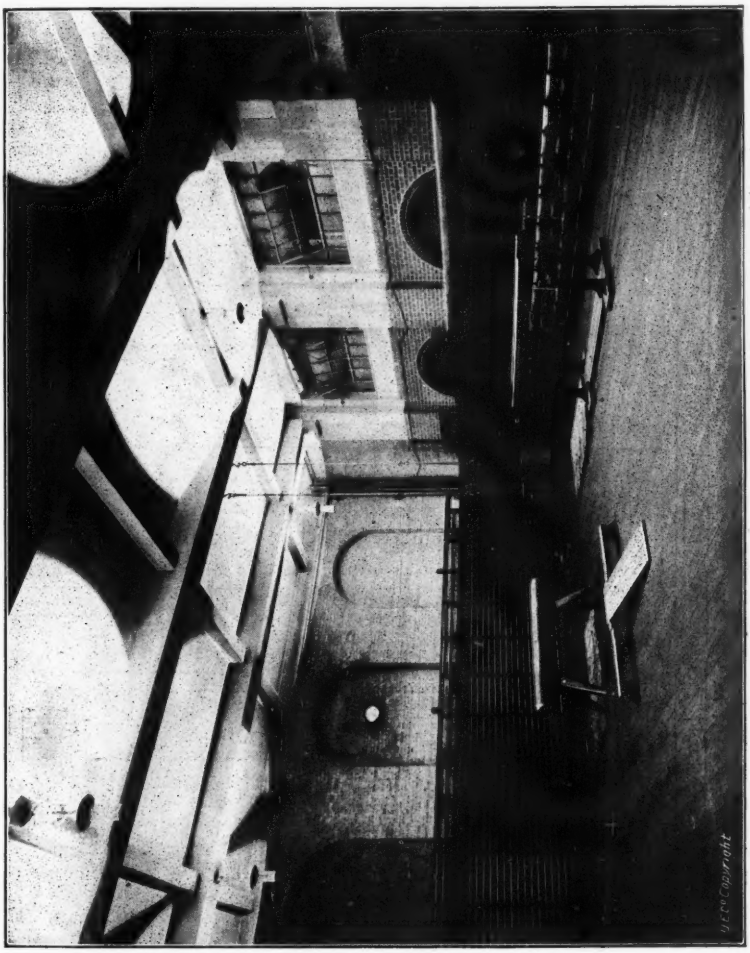


FIG. 1.—Gymnasium at London Day Training College (Slide No. 4).

The room, which was one of a number in a large school of domestic economy, was ultimately lighted by inverted arc

TECHNICAL DATA RELATING TO SLIDES ILLUSTRATING THE LIGHTING OF EDUCATIONAL INSTITUTIONS, SHOWN AT THE MEETING OF THE ILLUMINATING ENGINEERING SOCIETY, HELD ON MARCH 14TH 1911.

SLIDE NO.	INSTITUTION.	TYPE OF LIGHTING	ROOM SHOWN.	HEIGHT OF ROOM.	FLOOR AREA SQ. FT.	CURRENT CONSUMPTION IN WATTS PER SQ. FT.	POSITION IN WHICH READINGS WERE MADE.	NUMBER OF READINGS TAKEN	ACTUAL ILLUMINATION IN FOOT CANDLES. AVERAGE	MAX.	MIN.	DIVERSITY CO-EFFICIENT = MAX/MIN.
1	LONDON DAY TRAINING COLLEGE W.C.	TRUE INVERTED	LARGE LABORATORY	20 FT.	1440	1·38	ON BENCHES AND TABLES.	16	3·06	4·2	2·0	2·1
"	" " " " "	" "	" "	"	"	"	ON BLACKBOARD ON EASEL.	9	2·07	2·3	1·9	1·21
"	" " " " "	" "	" "	"	"	"	ON BLACKBOARD ON LEFT SIDE OF PHOTO.	5	1·68	1·8	1·6	1·12
2	" " " " "	" "	MUSEUM.	12 FT.	760	1·31	ON TABLES & CASES.	13	4·0	5·4	3·0	1·8
"	" " " " "	" "	" "	"	"	"	ON BLACKBOARD ON EASEL.	9	2·37	2·6	2·2	1·18
3	" " " " "	" "	MANUEL TRAINING ROOM.	"	1248	1·6	ON BENCHES AND TABLE	16	4·84	6·1	3·0	2·03
"	" " " " "	" "	" "	"	"	"	ON BLACKBOARD OVER TEACHERS DESK.	9	2·6	2·8	2·5	1·12
4	" " " " "	" "	GYMNASIUM	20 FT.	1950	1·02	ON FLOOR.	9	2·64	3·0	2·4	1·25
5	" " " " "	SEMI-INDIRECT	LECTURE HALL	18 FT.	2500	1·32	ON BENCHES FACING STUDENTS.	17	4·12	4·8	2·2	2·18
"	" " " " "	" "	" "	"	"	"	ON BLACKBOARD OVER LECTURING TABLE	12	2·64	3·2	2·0	1·6
6	WESTMINSTER TECH. INST. S.W.	TRUE INVERTED	GAS TESTING LABORATORY	14 FT. 9 IN.	554	2·2	ON DESKS AND BENCH.	8	5·25	5·8	4·9	1·2
"	" " " " "	" "	" "	"	"	"	ON BLACKBOARD	9	2·58	3·1	1·9	1·63
7	" " " " "	" "	WOOD WORKING DEPT.	"	864	2·31	ON BENCHES.	10	6·18	7·0	4·8	1·46
8	" " " " "	" "	ANTIQUE ART ROOM.	"	"	"	ON FLOOR.	8	4·3	5·0	4·0	1·25
9	" " " " "	" "	MENS LIFE MODELLING ROOM.	"	479	1·01	ON FLOOR.	5	4·1	4·9	3·5	1·76
10	" " " " "	" "	ELEMENTARY ART ROOM.	"	544	1·83	ON DESKS IN FRONT OF STUDENTS & ON TEACHERS TABLE.	10	3·8	5·2	2·9	1·78
"	" " " " "	" "	" "	"	"	"	ON BLACKBOARD	10	2·51	2·9	1·7	1·7
11	" " " " "	" "	WOMENS LIFE PAINTING DEPT.	VARIES HEIGHT TO OVER REFLECTORS 13 FT.	1452	1·36	ON FLOOR.	6	5·21	6·5	4·0	1·62.

lamps giving an average of 8·56 foot-candles over the whole of the work-tables.

As regards the slides I should just like to say that these have in each case been prepared from absolutely untouched negatives, taken between 7.30 and 10 P.M. by the actual light emitted by the lamps shown.

I would also add that the photographs shown, and the measurements given in the table which follows, represent the conditions *as found*, and not necessarily such as are recommended. For instance, in slide No. 4 (reproduced p. 228) the lamps are wrongly hung, with the result that no use is made of much of the reflecting surface provided by the white ceiling. Had the lamps been lowered sufficiently to illuminate evenly the whole of the ceiling, the illumination on the floor would undoubtedly have been higher and more even.

Detailed particulars of the various rooms, of the current consumption, and of the light measurements obtained, are given in the adjacent table, and as showing what can be done by suitable indirect lighting, I would instance the diversity co-efficient in respect of the room illustrated by slide No. 6 (see p. 221) which is quite the most satisfactory which I have so far come across. It may interest some of those present to know that the whole of the light measurements were made with the Holophane Lumeter, the figures given being the mean of two sets of readings by separate observers.

MR. F. W. GOODENOUGH* (Gas Light & Coke Co.) said all the members of the Society would agree with him that they were very much indebted to Dr. Kerr and Dr. Harman for their valuable contributions on this subject. With Dr. Kerr's paper he was not concerned, because it dealt with daylight illumination, and naturally he preferred that daylight illumination should be as limited as possible! In his opinion a discussion of this character helped to prove the value of the Society, and so far as practical results issued from the discussion, the reputation of the Society would be considerably enhanced if they could arrive at a standard illumination for various types of school-rooms, lecture halls, and so forth. Such a work would be of very great value to the community at large. The standard of illumination mentioned by Dr. Harman as having been given by Sir H. Halford seemed rather out of date at the present time; we wanted a better illumination nowadays than one which merely enabled us to see the ace of clubs. Dr. Harman's remarks that the naked jet was fast vanishing, he thought, was a reflection upon the enterprise of the British nation. Eight years ago he visited all the principal Continental cities to investigate systems of street and other illumination, and the most prominent thing which struck him during his inquiries was the entire absence at that date of the naked jet on the Continent, whilst we in this country were still using about 50 per cent of naked lights instead of incandescent mantles. Two or three years after that, he had occasion to approach the War Office on the subject of the illumination of barracks, many of which were still lighted with naked burners, and he received the very characteristic reply that the subject of incandescent lighting had been under consideration for some years, and that the War Office were thinking of taking action in the matter. He would only say to everyone concerned in the lighting of scholastic establishments that the sooner the naked jet became as absolutely unknown in this country as it was on the Continent the better for every one.

He now wished to join issue with Dr. Harman on the question of inverted burners. Dr. Harman said in his paper that the one sole advantage of the inverted burner was the absence of shadow below the light, but he did not think Dr. Harman had obtained all the information that he might have on the question of the relative efficiency of the inverted and upright burner. Careful tests showed that at least 33⅓ per cent more light per cubic foot of gas used could be obtained from an inverted burner compared with an upright

* Some further details of gaslighted schools since received will be found on p. 239.

burner, which was, of course, a very substantial advantage of the one over the other.

Some tests made by the kind permission of the authorities in the Westminster City School and the L.C.C. school at Barnsbury had demonstrated this fact very conclusively. Where the inverted burner was used, the average illumination was 4·5 foot-candles with a consumption of gas of 3·78 cubic feet per 100 sq. ft. of school, whereas with the upright burner the average illumination was 4·4 foot-candles—practically the same—but the consumption of gas instead of 3·78 cubic feet was 5·85 cubic feet per 100 sq. ft. of school. Comparable results had also been obtained in other schools. Dr. Harman had spoken of sensitiveness to variations in pressure of upright burners. He did not know whether that was a misprint in the paper; it seemed that Dr. Harman meant that it was one of the points against inverted burners. On this point he would only say that the

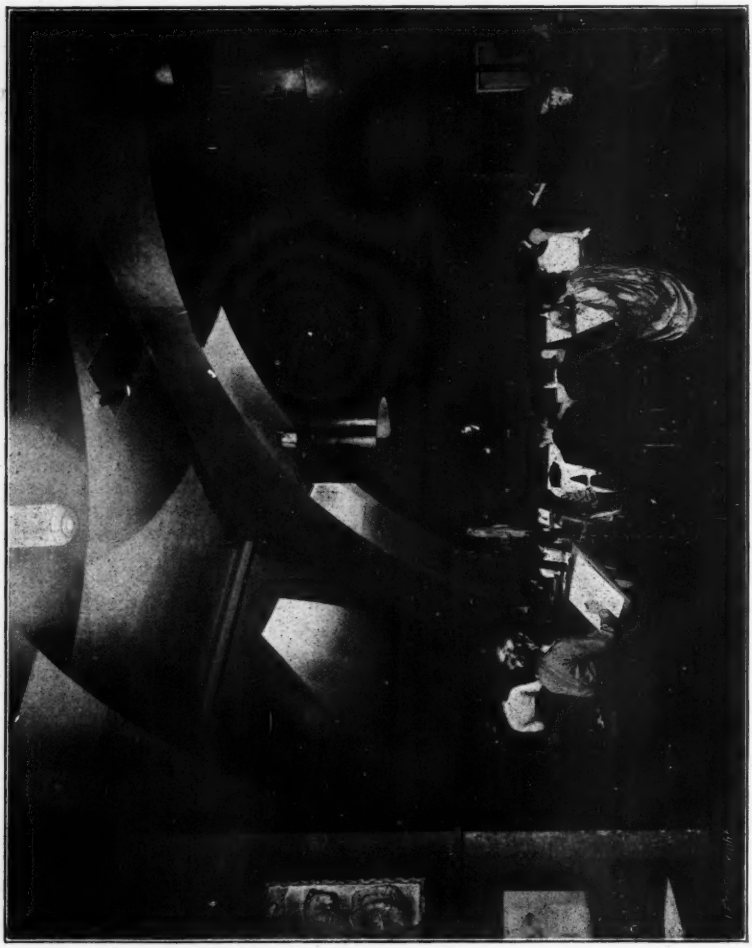


FIG. 2.—Art Room at Westminster Technical Institute (Mr. Ritchie, see p. 223).

gas supply to every school, or, indeed, every building, should be governed from the meter, in order that there should be no variation in pressure. It was a comparatively easy and inexpensive thing to do, and it made both for economy and efficiency. Dr. Harman had also remarked that inverted burners had not proved satisfactory in the hands of the average school keeper, but in his experience very few incandescent burners of any description proved quite satisfactory in the hands of the average school keeper, and he would again urge the point that he had previously urged before the Society, of the advantage of every consumer placing the maintenance of incandescent burners in the hands of the Gas Co., who employed skilled men entirely for that work, and whose interest lay in giving their consumers the most efficient system of lighting. The comparative results given by Dr. Harman of the use of different kinds of reflectors were exceedingly interesting, and demonstrated very conclusively the value of the 90° reflector that was described and illustrated in his paper, but he was sorry to see that on the score of cheapness a compromise had been adopted instead of the 90° reflector. He thought it was a great pity that any public authority, on the score of cheapness, should go in for a system of lighting that was not the best, because he was sure that the satisfactory lighting of schools was of vital importance to the rising generation. Then there was the truly British fact that the lights in the classrooms were usually set rather with a view to symmetry than to good lighting. That was very like the British nation. The position of the lights was determined in a very haphazard fashion, and the desks, as Mr. Baker had said, were sometimes rushed in at the last moment, and the lights also. He hoped that this discussion, in which the L.C.C., through their officials, had taken so much interest, would lead to this state of things rapidly passing away. He would like to mention, in connexion with the tests that he had been taking, the difference in illumination found in some cases between the writing surfaces and the reading surfaces of the desks in the L.C.C. schools where the desks were adjustable. Particularly at the backs of the rooms, it was found that the reading surface was very badly illuminated in comparison with the writing surfaces. This he believed was due to the dark dadoes that were common in these schools, and which had a very much more marked effect upon the illumination of the desks at the back of the room, especially when set up for reading purposes, than was the case in any other part of the room. This point certainly needed consideration from those responsible for the lighting of schools.

Another point upon which he would be expected, and would like, to say a few words was the connexion between lighting and ventilation in schools. Where gas was used, it could be utilized very materially for assisting ventilation. Dr. Harman, in referring to another system of lighting, mentioned the advantage of the absence of consumption of air and so forth, but he would be very glad if Dr. Harman could get the L.C.C. to carry out some tests of the atmosphere of rooms when lighted by gas and when lighted otherwise, or even not lighted at all. Some tests on this point had recently been published. They were made by the Medical Superintendent of the Lewisham Infirmary, and he was led to make them as the result of some experiments at the offices of the Society of Medical Officers of Health. The results had been published in *The Medical Magazine*, and they showed that the atmosphere of a ward lighted by gas was precisely as hygienic—neither more nor less—as a similar ward without any lighting at all. There was only normal ventilation in the ward lighted by gas, but the fact that the gas stimulated the ventilation resulted in there being no vitiation of the air. He would like Dr. Harman to consider this subject and see whether he could get the L.C.C. to carry out some tests on this very interesting point.

The Gas Light and Coke Company had taken a number of photographs of schools as good illustrations of lighting in their district, and he would ask his assistant, Mr. Clarke, to give the

particulars in connexion with these tests, as he had superintended them.

MR. J. G. CLARKE,* in describing the slides thrown on the screen, said that the L.C.C. Barnsbury school was typical of the gas lighting in most of the L.C.C. schools. The classroom was lighted by six Kern burners with "squat" globes. The area of the room shown was 750 sq. ft., with accommodation for 80 scholars. The mean illumination was 2·61 foot-candles, and the diversity coefficient 1·52. A classroom in the Westminster City School was shown, lighted by four inverted burners, screened by opal shades, which gave a mean illumination on the desks of 2·36 foot-candles. Another classroom in the same school, lighted by upright burners, shaded, has a mean illumination of 2·7 foot-candles. The consumption of gas per sq. ft. was considerably higher than that in the room lighted by inverted burners, so that

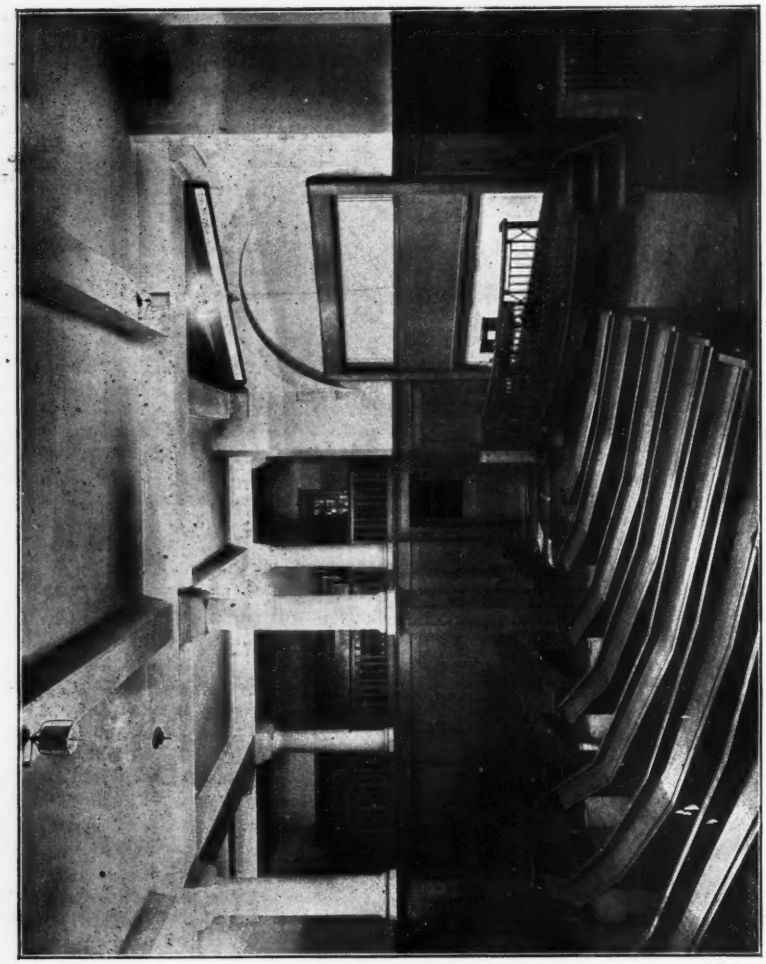


FIG. 3.—Lecture Hall at London Day Training College, Slide No. 5 (Mr. Ritchie, see p. 223).

* See also p. 239.

although a very excellent illuminating effect could be obtained by upright incandescent gas burners, it was more costly than the same thing done by the inverted system.

At the East Ham Board School inverted gas lamps were used, hung about 30 in. from the ceiling and screened by enamelled shades. The room shown had accommodation for 60 scholars, and the mean illumination was 3·1 foot-candles.

A series of photographs was then shown of halls in various schools. At the Barnsbury school the area of the hall was 2,300 sq. ft., and the mean illumination on the floor 2·25 foot-candles. The diversity coefficient was very low, 1·2 showing a very uniform illumination. The hall of the Westminster City School had an area of 2,755 sq. ft., and here again a very uniform illumination was obtained, the average being 2·3 foot-candles. At the East Ham Board School the hall has an area of 2,560 sq. ft., and is lighted by inverted lamps having white enamelled shades, the lamps being arranged centrally down the hall. The average illumination on the floor was 2·9 foot-candles.

Two slides were then shown of school workshops. The first was the workshop at the L.C.C. Barnsbury school, which has an area of about 957 sq. ft., and is lighted by upright burners, fitted with the new opal shade described in Dr. Harman's paper. The illumination on the benches is practically uniform, and works out at 4·4 foot-candles. The other was the workshop at the Westminster City School, which was lighted by inverted burners. Here again a very good illumination is obtained, the average being 4·5 foot-candles. This room has 15 benches, and accommodates 30 students. It will be noticed that considerable economy is effected by the use of inverted burners.

The lighting of the art room at the Westminster City School is of a rather mixed character, owing to the necessity for having a very wide choice of illumination. Here the range is from 6 to 15 foot-candles in different parts of the room. The model in the middle of the room is illuminated by an inverted lamp fitted with a parabolic shade, the illumination in a vertical plane near the model being between 10 and 11 foot-candles. The chemical laboratory in the Westminster City School is lighted by inverted burners similar to those previously described, and the average illumination on the benches is 3·4 foot-candles.

THE CHAIRMAN pointed out that the series of experiments by Mr. Gaster, Mr. Dow, and Mr. Clark were all carried out with the same instrument, namely the Holophane Lumeter.

MR. RITCHIE added that his results had also been obtained with the Lumeter.

DR. PISANI said he had been in India for many years, and had been interested in the causation of cataract. Many people attributed cataract to the ultra-violet rays, but he had not found any evidence whatsoever of this. Indeed, he thought there was very important evidence that ultra-violet rays were not the cause of ordinary cataract, for the reason that in mountainous regions like Switzerland and Norway, where the ultra-violet rays were very prevalent, cataract is comparatively rare.

DR. E. H. T. NASH (Medical Officer of Health and School Medical Officer, Wimbledon), said that his sphere of influence was much more connected with natural lighting than with artificial lighting, and he hoped that Dr. Kerr's section of the discussion would receive a proper share of attention. The lighting of blackboards in schools, particularly in infants' schools, was a very important matter, and he would be very glad if the Society could do something to set up a standard of daylight illumination in such schools. Coupled also with this was the necessity for some standard of contrasts, as certain colours were inadmissible in infant schools on account of want of contrast. This had been particularly brought to his notice by watching infants being taught to read on the Dale system, which is generally done with coloured letters hung on a blackboard, or modified by the letters being written on the blackboard with coloured chalks, mostly in reds and blues, and it is these colours which give most of

the trouble, particularly the blues and purples. It must be realized that reading, with a child, is not only a mental effort but a visual effort, and that anything which tends to make the visual effort greater increases the mental effort and the work of the teacher in attempting to make the child learn. Therefore it is of extreme importance that the visual effort shall be reduced to the lowest possible amount, firstly by adequate lighting of the blackboard, and secondly by the use of only those chalks which give an adequate contrast. He demonstrated on the blackboard, by means of chalks which were in everyday use in many schools, that certain of these colours were quite invisible at short distances. He did not think the Society quite realized the far-reaching effect which this discussion was going to have. It would affect more particularly the size, design, and shape of classrooms, and also the size and shape of the windows. The Board of Education laid down that

FIG. 4.—Art Room at Westminster Technical Institute (Mr. Ritchie, see p. 223).

the ideal classroom should be square, whereas this discussion confirmed the opinion which he had held for a long time, that the Continental authorities were right and that the oblong classroom was a better shape than the square one. The examples shown by Messrs. Gaster and Dow showed conclusively that the row of desks along the wall furthest from the window were most inadequately lighted, seldom being above ·75 foot-candles, and often as low as ·4; and it seemed an immense improvement, with an equal number of children, to make the classroom longer and narrower, and to replace the row of desks along the wall furthest from the window by an extra row of desks at the back of the class room. These ideas, of course, were based on the fundamental principle that it is advisable to have all the light coming from the left. The Illuminating Engineering Society would be doing a good work if it pushed home the inadequate lighting of a square classroom. The Society should also make experiments with regard to the position of the blackboards and the materials of which they are made, with regard to getting the best lighting, and also with regard to the abolition of blackboard glare, most of which can be got over by vertical tilting of the board. The present practice with a movable blackboard is to place it in front of the class in the corner furthest from the window, as being the only position in which all the class can see it, and yet this is the position in the room which one rarely finds above ·75 foot-candles. What he advocated was the abolition of movable blackboards in favour of fixed blackboards occupying the greater part of the length of the facing wall. The position which Dr. Bishop Harman had shown in his classroom arrangements was quite wrong, as he also had chosen the worst lighted half of the facing wall.

Another important point which had been brought out was the relatively bad lighting of the blackboard, even when well placed on the facing wall, as compared with the lighting of the desks. This was due to the practice of not taking the window space right up to the facing wall, and it had been shown that in many cases where the desk lighting was well up to 2 foot-candles the blackboard lighting seldom reached one or even ·75 foot-candles. He advocated taking the windows across the whole length of the classroom and abolishing the mullions, as Mr. Kirby had done in his Undercliffe School at Bradford. Unfortunately most of the schools throughout the country were built with heavy mullions, and as long as the architect got one-fifth of the floor area as window space he was content. At the same time it must be pointed out that this increase of window area produced fresh problems with regard to heating, and it may be necessary to increase the heating capacity, or even double-glaze the windows, owing to the rapid cooling produced in cold weather and the consequent interference with ventilation. Where free ventilation and large windows had been tried, it had been found necessary in some cases to increase the heating capacity by 50 per cent. Seeing how many problems school lighting touched upon, they would all realize the immense importance of the subject and the discussion.

As a School Medical Officer, he welcomed the discussion most heartily, because he thought it would strengthen their hands. School Medical Officers were being scoffed at for knowing nothing about these matters, but some of them at any rate were keenly alive to the importance of these matters in the solution of the problem of the maintenance of the health of the children by proper environment, and believed that one of the most important factors in this was plenty of light, both natural and artificial.

Mr. A. Heron Ryan-Tenison, F.R.I.B.A., as an architect with considerable experience in school design, said there were two points with reference to the natural lighting of school buildings which troubled the architect at the present time. One was the practical impossibility of securing satisfactory natural lighting in congested districts where the site had become surrounded by buildings. The other was the difficulty of obtaining good

natural lighting at the back of class-rooms, that is to say, beyond a certain distance from the external or window wall, subsidiary lighting being impossible.

The Board of Education required about 1 ft. of glass area to every 5 ft. of floor area for classrooms, which gave excellent results up to 22 ft. from the windows, but, as the late Architect to the Education Department of the L.C.C. once pointed out to the speaker, not beyond that distance except by subsidiary lighting.

The Board of Education Code rules permitted classrooms having a depth from the window wall of 24 ft. 6 in., and it therefore stood to reason, and the speaker had verified this, that the additional 2 ft. 6 in. was not well lighted.

On the question of gas, &c., *v.* electric lighting, it would be very interesting for architects to know how far the advocates of the various methods of artificial lighting would space their lamps apart. The speaker had generally adopted a distance of about 7 ft. 6 in. as the spacing from lamp to lamp when using a 16 c.-p. lamp, that is to say, that no child should be more than a distance of 7 ft. 6 in. from a light, the rays from which would fall at an angle of 45°. It will be noted that this brings the majority of the class to a lesser distance than the spacing above named.

Mr. J. Darch: In Dr. Harman's excellent paper on 'The Artificial Lighting of School Rooms,' he has made (p. 158) what he has termed a "modest demand" for a minimum desk illumination of 10 metre-candles —a little under 1 foot-candle. The demand is much too modest; for, as a working and standard minimum, it might, with advantage, have been 3 or, at least, 2 foot-candles. I am aware that it has been shown that visual acuity with ordinary type is possible at an illumination of 1 foot-candle, but a bare physical possibility is quite a different thing to a permissible minimum, and danger lies in the fact that a published opinion of Dr. Harman might influence the makers of regulations and bye-laws, and unfortunately the tax-payer and the administrator usually feel that they have done their duty if they keep within a stipulated minimum.

But visual acuity depends not only upon the amount of illumination falling upon a surface, but also upon the colour of that surface and the size of the detail thereon. Let us consider some of the causes of eye-strain in schools. There are the map studies, in which minute detail, often on dark-coloured ground, has to be searched out; there is sight singing, where the eye has to grasp very small lines and dots in a short time; there is geometry, with its faint pencil lines and its needle pricks to be discerned; even the studies in arithmetic are made a little trying in a poor light by reason of the common dark-coloured scribbling paper —good enough otherwise—which the L.C.C. supply; while the eye strain in needlework has been so obvious that in many schools this work has often to be postponed. I claim, therefore, that for official purposes 30 metre-candles or, say, 3 foot-candles, be considered a standard minimum for ordinary desk illumination, while the class-rooms for drawing and needle-work have a minimum of 8 foot-candles.

I was glad to observe Dr. Harman's references to oil lighting. There is no reason why the village school should not enjoy as scientific and as artistic an illumination from oil lamps as from the more modern forms of light: they need only to be suitably designed and arranged, the candle-power sufficient, the bare lights screened, the general lighting well diffused, and separate local lighting provided where necessary.

Dr. Harman recommends (p. 163) a certain opal shade set 6 ft. 6 in. from the floor. I have measured a typical classroom in one of our newest L.C.C. schools in south London, and prepared a vertical section (p. 231), in which I have shown the lamps as recommended by Dr. Harman, and in which it will be seen that the opal shade, with a surface brightness of 1 c.-p. per sq. in. or more, is set right before the eyes of the children, and is bound to baffle their efforts to discern the blackboard or

diagrams. The remedy is simple. Either keep the lights up to within 2 or 3 ft. of the ceiling and add screens if necessary, or, if the lights must be 6 ft. 6 in. from the floor, then protect both the childrens' and teachers' eyes by means of opaque shades — such, for example, as that shown on page 208, where the top is left open for illuminating the ceiling and upper walls.

It is with much pleasure that I support Dr. Harman's view of the need for a special and different treatment of the teachers' portion of the room. It is the place of exhibit and display, and should be suitably provided with covered lights for that purpose.

MR. JUSTUS ECK: The Society is to be congratulated upon having, on this occasion, two papers dealing with the illumination of the same class of premises, respectively by daylight and by artificial light, because in my mind it is most desirable that buildings should be so constructed as to have good illumination both by day and by night: this can only be provided by the architect so designing his building that the daylight effects are as good and as even as those produced by the artificial illuminant adopted.

Many school-rooms and similar buildings suffer, as has been shown by the measurements, suffer from bad daylight distribution, which can be to a large

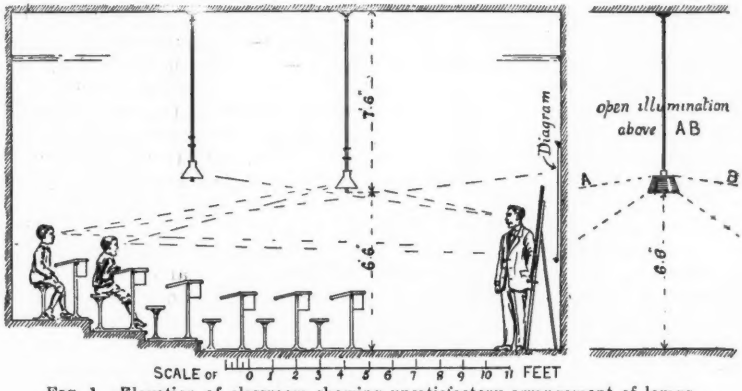


FIG. 1.—Elevation of classroom showing unsatisfactory arrangement of lamps and recommended form of shade.

I must take exception to the statement on p. 164 that high voltages and intensely powerful lights mean uneven distribution and black shadows. On the contrary, the greater the intensity of the light, the easier it is to modify and diffuse, consequently the more even will be the distribution and the softer the shadows

Nor should "the glowing filament" (p. 164) need reducing in intensity; for, in the first place, it should not be visible to the eye, and in the second place, it should not be prevented by glass or anything else from shedding its fullest illumination upon desk and ceiling in order to obtain the best diffusion, the most pleasing effect and the greatest visual acuity.

extent remedied by adopting a suitable design of window and arrangement of the decoration. The windows should be carried up high, and the upper portion provided with prismatic glass, such as that known as "luxfer," to carry the light rays horizontally to the upper part of the opposite wall. The decoration should consist of a good white frieze going down as far from the ceiling as to the bottom level of the prismatic glass, and this should be turned by an easy cove into the ceiling, and the whole of this upper part be washed with a truly white colour. The lower part may well consist of a pale green colour. A room of this class lends itself excellently also to artificial illumination, especially the indirect

illumination provided by arc lamps or similar powerful light sources.

It has a further advantage in that the eye finds in the lower green, or

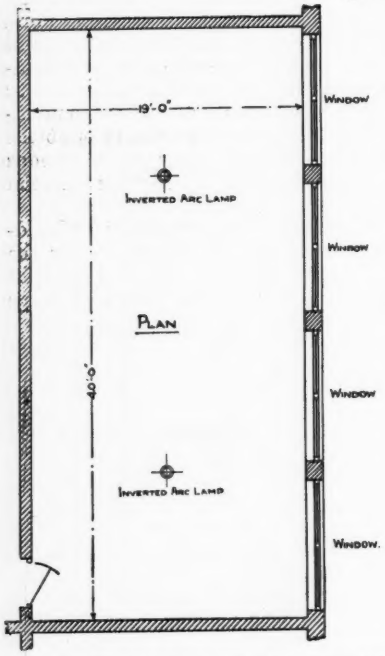


FIG. 1.—Plan of room showing suggested arrangement of daylight and artificial light.

other coloured surface, a certain amount of rest or variation in illumination, which would not be achieved if the ideal efficiently illuminated room, viz., one with a white ceiling, white walls, and white floor ground, was provided: the tinted contrast of wall and floor, while not largely affecting the light efficiency of the room, adds greatly to its comfort in use and elegance in appearance.

I should like to take this opportunity of suggesting that the official editors of the transactions of the Society should obtain permission of all contributors of papers or to the discussion, of converting the measurements given to one common standard, either the lux, the meter-candle, or the foot-candle, so that when reading *The Illuminating Engineer* all comparisons between figures can be readily made with certainty.

Coming to Dr. Bishop Harman's paper, I regret to see that he sanctions the very low standard of minimum illumination of 1 foot-candle: I think this is quite an error, and quite out of keeping with the demand at the present time of scholars and workers.

There is no doubt that the demand on the eye in the way of good illumination is equally, if not more, severe on the pupil in a school than on a worker in a fine industry, and it is, therefore interesting to note that Holland has a fixed minimum of illumination of about 1·5 foot-candles for fine industries, while at the recent Second Congress on Industrial Diseases, which I had the honour of attending—in company with Mr. Leon Gaster—as your delegate, Dr. Broca read a most interesting paper, and gave a scientific demonstration, to the effect that the minimum illumination of schools and similar places should be something over 3 foot-candles, his own figures being about $3\frac{1}{2}$ to 4.

The interesting figures and particulars given by Mr. Gaster and Mr. Dow in their researches amongst the illumination of various London schools and colleges implies that this figure is not usually provided, although it approaches $2\frac{1}{2}$ to 3 foot-candles; but I note with pleasure that they suggest a higher value of 5 to 10 foot-candles seems required where fine work, sewing, &c., is carried on.

As it is obvious that the class of

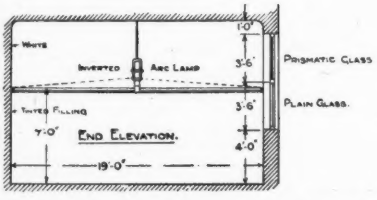


FIG. 2.—Elevation of room showing suggested scheme of decoration and lighting.

work carried on in a school-room cannot always be maintained at the same, it seems to me advisable that a higher standard of illumination suggested as

a minimum by Dr. Broca should be adhered to.

Another disadvantage of adopting such a low standard of illumination as 1 foot-candle is that the question of glare has to be more carefully considered, because if the mean illumination is so low, the intrinsic brilliancy of the illumination source must be equally low, otherwise glare effects are produced, and I venture to suggest that no modern economical form of illuminant is suitable for a room which has the low figure of 1 foot-candle.

It would be of interest to look into the effect of the colour of the light sources: this varies considerably between gas applied either in flame or mantle illumination, incandescent filaments, whether carbon or metallic, and arc lamps, and certainly has a bearing where demonstrations are given with coloured materials, or by means of coloured chalks on the black-board.

Coming again to the subject of indirect lighting by means of arc lamps, Dr. Bishop Harman instances the case of the Anatomical Laboratory at the Cambridge University fitted with inverted arc lamps some fifteen years ago, and from this particular case draws a general conclusion not in favour of arc lamp lighting. Fifteen years ago is an era in arc lamps; many improvements have since been made, both in the direction of efficiency of the arc, suitability of reflectors, and regularity of working, and as I understand the current supplied was alternating current, it would be particularly interesting to know what kind of a reflector was used with this form of arc lamp, which is not so suitable for indirect lighting as the direct current.

Looking further into the matter, as I understand the operations carried on in the Anatomical Laboratory were those of dissection, it is quite clear that unless the minimum illumination was carried up to something like 10 foot-candles, no successful result could be anticipated, and probably it will be found that the illumination on the dissected object is now raised to something like 20 to 30 foot-candles, which, bearing in mind the delicacy of the work and the slight differences in colour, does not seem to be excessive; an anatomical laboratory for dissection seems to me widely removed from a school or lecture-room in lighting requirements.

One of the speakers at the previous meeting stated that the cost both of installing and maintaining of indirect lighting arc lamps was in excess of that of metallic filament electric lighting. I have taken the opportunity of obtaining an estimate from a well-known London electrical contractor acquainted with the London requirements, and I find that the cost of metallic filament lamp wiring would be from 58 per cent to 86 per cent in excess of that of arc lamp wiring, in both cases including the lamps and everything requisite to turn on the current. The quantity of energy absorbed would, with the metallic filament lamp lighting, be from 50 per cent to 80 per cent greater, and in this case I base my figures on the Westminster Testing Laboratory's recent tests, while the light in the case of the arc lamps would be from 50 per cent to 55 per cent greater, and would have the advantage of remaining constant at all times, whereas the metallic filament lamp lighting diminishes in the course of time. I have set off in the above figures the cost of carboning the lamps as against the cost of the periodical renewing of the metal filament lamps.

Rooms fitted with indirect arc lighting have the advantage of not being affected by the introduction of the furniture at a subsequent date; what is provided is even, shadowless, steady room lighting; desks, &c., can then be brought in at the last moment and placed as desired, as also can the black-board, which will not suffer from the distressing feature of black-board glare: the light will have a high angle, be shadowless, and the supervision of the pupils will be of the best, whilst there will be no eye fatigue, because the light source will be totally obscured and only the luminous ceiling and frieze will be visible.

In this connexion it is well to remember that if the lamp is placed at a suitable distance from the ceiling, the ceiling illumination can be practically

even, whilst if good quality carbons are used in connexion with the arc lamps of suitable design, perfectly steady light can be obtained as an every-day matter, without any expert trimming being required.

The figures given with respect to the experiments made at Munich show the low diversity co-efficiency that is obtained with inverted arc lighting, and this low figure has been accentuated by the interesting views and data provided by Mr. Ritchie, his figures in some cases being markedly better not only than those obtained in Germany, but most markedly better than anything given for any other form of lighting. In comparison with this, I would refer you to the Tables II. and V. shown by Mr. Gaster, from which it is clear that the ordinary diversity co-efficient must often be exceedingly high.

I would also like to ask Mr. Dow whether the photograph he showed of the Central Technical College lecture-room was taken with the arc lamp alight or not.

Various advantages have been claimed for gas lighting, one amongst them being the ventilation of the school-room, but I would like to emphasize one disadvantage of gas, viz., the high temperature reached in the rooms: this must be a serious drawback both in winter and more especially in summer.

Mr. V. H. Mackinney pointed out that to space 16 c.-p. lamps 7½ ft. apart as Dr. Harman had suggested would involve an average consumption of one-third of a watt per square foot: this was not enough for good illumination, and it would be difficult to get beyond 1 to 1½ candle-feet with the present light sources available. This led him to suggest that there was a need for a more generous allowance as regards energy consumption in school lighting. Indirect lighting was an excellent method in some circumstances. Efforts were now being made to scheme out indirect lighting with metal filament lamps with a reasonably low consumption of energy. Mr. Ritchie had shown some admirable photographs of indirect lighting with arc lamps. A difficulty which was apt to be encountered with poor classes of carbons was the tendency to flicker: this was objectionable for close drawing work and the like. He would like to emphasize the suggestion put forward at the last meeting of the Society, that with an increase in intrinsic brilliancy it was almost always necessary to have a greater amount of illumination on the working plane.

Mr. Mackinney next proceeded to exhibit a photograph showing his new form of metallic reflector, covering a tubular lamp, which was designed to give an absolutely even illumination over an extended area. Used as a means of indirect lighting, he anticipated that this reflector might lead to much more efficient results than were at present obtainable with incandescent lamps. Indeed, he thought there was little doubt that 80 per cent of the useful light could be reflected on to the working plane by the aid of such a light unit. In addition, the reflector was ideal in operation and very economical for black-board lighting—a difficult problem to which most speakers had referred. With regard to the standard illumination for school-rooms, he thought it would be more useful to state a definite permissible minimum value, according to the nature of the work that the rooms were to be put to, rather than to aim at a uniform high value. The question raised by Mr. Baker, namely, the difficulty of having the desks in position early enough to determine the positions of the lights, simply pointed to the need of greater co-operation between the architects, lighting engineers, the medical profession, and of the authorities concerned with schools.

Mr. R. J. Wallis-Jones (*communicated*): With reference to the most interesting communications of Messrs. Gaster and Dow, it would, in my opinion, add considerably to the value of the data given as to the illumination of various schools if the authors could also state the colouring of the walls of the rooms. I have found that walls distempered a light green tint resembling the colour of a heron's egg not only gave a good illuminating

effect, but also had a restful tendency. I would also like to know if the observations of illumination in foot-candles were measured by the same observer.

From my own practice I may mention that I have recently obtained very good results in high class-rooms by using holophane "arc" fittings, *i.e.*, metal filament lamps frosted with individual holophane shades, several of which are grouped in a cluster beneath a holophane dish of large diameter.

With regard to black-board lighting, I agree with some of the speakers that a black-board should be treated in the same way as a stage or picture—that is to say, the board itself should be illuminated, but the source of illumination totally hidden from the students in the class.

I also advocate that where incandescent electric lamps in class-rooms are fixed within the range of vision they should in all cases be frosted so that no portion of the filament is visible.

MR. S. COWPER-COLES (*communicated*): Thinking it may be of interest, I have placed on the table some specimens of translucent glass, which I have found very effective for reducing the glare of bright lights, such as metallic filaments.

The translucent glass is ordinary glass coated with a very thin film of gold, which acts as a gold reflector and at the same time transmits a certain proportion of the light as green light. If a translucent glass shade is placed in front of the source of light or below it, the thin gold film on the glass acts as a gold reflector and throws a gold-coloured light on the walls and ceiling, and the transmitted light is of a soft green colour. The combination gives a very restful and pleasing light to work by.

[These specimens were exhibited at the meeting.—Ed.]

DR. KERR, in a brief reply, said there was no doubt that the day of rule of thumb in relation to schools had passed away as far as illumination was concerned, but he thought the Society might go a little further, because schools were only one thing, libraries were another, and so on. We should undoubtedly ultimately adopt some standard of lighting best suited to meet hygienic requirements. The difficulty had been to measure lighting, and in connexion with the recent legislation about bakehouses, there was great difficulty in determining the amount of illumination. He was of the opinion that legislation in respect of lighting would be largely extended as soon as the means for standardizing the light became better known. Could the Council of the Society form a committee to consider the question of school lighting, and draw up a few simple rules in relation to classrooms, large rooms, black-boards, &c., simply as a hint to educational authorities throughout the country?

DR. N. BISHOP HARMAN, in reply, said that he ventured to express his regret that so much of the discussion had turned upon artificial lighting rather than upon the subject introduced by Dr. Kerr—natural lighting.

It almost seemed some speakers forgot that even in London the work of elementary schools was still performed by the light of the sun, and that artificial light was an auxiliary of no very frequent use! For his part he would like to see work stopped in elementary schools with the cessation of efficient daylight.

As Dr. Kerr had indicated, the determination of the most effective arrangement of windows in classrooms was one of the highest importance. On our ideas of what that should be turned the whole plan of a building; and were we wrong in that, our sins were visited upon the children to the third and fourth generation. A mistake in artificial lighting was a comparatively small matter—it cost little to scrap a few yards of gas pipe or electric wire.

On the subject of windows, he thought the observations of Mr. P. J. Waldram on high angle lighting of great value. He preferred the suggestion of the "glazed frieze" to top lights. There was something prison-like in a room without a natural window, and children were very susceptible to the emotional influences exerted by their surroundings.

With reference to artificial lighting, it appeared there was a general fundamental agreement amongst speakers, but a wide diversity in recommendation of detail. It seemed some of this diversity arose from a very natural circumstance: speakers were recommending schemes for different purposes, so their schemes appeared to conflict. He held that the lighting of a hall, an art room, a technical shop, a chemical laboratory, and the forty-child classroom were not one and the same, but essentially different.

For that reason he objected to the sweeping advocacy of some speakers of the indirect method of illumination by ceiling reflection. He had said in his opening paper it was eminently suitable for some purposes but demonstrably unsuitable for others; the experience of Dr. R. S. Clay confirmed this statement. Further, one of the speakers had drawn attention to the fact that the brilliance of the ceiling was not without drawback; he would like to emphasize that. They were all conscious of the brilliance of the "ceiling of the world" and wore peaked caps for their comfort: they would need these in the classroom also!

He could not agree with the suggestion that the burning of gas in a room improved the ventilation: on this assumption, if one burner improved the conditions in this respect, ten burners should make the ventilation perfect—which was not borne out by experience. What became of the carbon, ammonium, and sulphur compounds produced by the purest coal gas?

There was only one possible arrangement by which the burning of gas can improve ventilation, and that was when each unit had a shaft fitted to carry off the products of combustion. That might seem to some an impossible demand, but he was old enough to remember a time prior to the introduction of electricity when merchant firms in the City of London prided themselves on their care of their staff in that such shafts were fitted to each gas burner!

On the subject of upright and inverted gas burners Mr. Goodenough had said the latter had a superior efficiency of 33⅓ per cent. He would like to know under what circumstances this surprising detailed percentage was obtained—what sort of shades were used? It might be the explanation was provided in the beautiful series of pictures shown, by comparing the lighting by these two burners; if that were so he understood readily, for in all but one instance the uprights were provided with the worst form of shade, and the inverted had a 90° reflector such as he advocated. His chief objection to the use of the inverted burner in the forty-child classroom was that the objectionable products of combustion were increased by the inverted position; they need only examine the metal fittings to see the effects in part.

Mr. Goodenough said the "average school keeper was not to be trusted with these fittings, the gas company's men should attend to them." In his opinion that statement effectually condemned them; they had no room in elementary schools for fittings required for occasional use that necessitated the regular attention of an extraordinary staff.

Blackboard illumination had properly received much attention. It was by no means an easy matter to deal with, particularly as regards daylight. On this point he would assure Dr. Nash that the position marked for the blackboard in the plan of his opening paper was only arrived at after careful elimination tests, which went to show that the board should be in front of the scholar farthest from the window. In this place alone could freedom from shine be secured.

On one point, and an important one, he would like to revise his position—that was on the matter of the *minimal illumination:* 10 metre-candles or 1 foot-candle was Cohn's original demand; it was arrived at by the effects on a sight test, and this he found gave a satisfactory "pass." The standard was made when present illuminating effects were impossible, so to demand more was absurd. Further, the standard is an "academic" one, if this word may be used. It implies the minimal light free from all

possible obstruction, or, put the other way, the light left when all reasonably possible obstructions have acted. That would not do for a working standard. He agreed, therefore, that a 3 foot-candle minimum illumination at the desk was a reasonable demand. That was the average he had planned for in his model room.

In conclusion, he said he was sure that the views put forward at this discussion and the work stimulated by it, such as that of Messrs. Gaster and Dow and Messrs. Ritchie and Clark, would bear valuable fruit. And in this connexion he thought the suggestion of Dr. Kerr of a Select Committee invaluable. He desired to thank their Society for permitting him to share in these discussions.

Mr. W. W. Webb, Lic. R.I.B.A., Mem. Roy. San. Inst. (*communicated*): I have read with absorbing interest the instructive paper by Dr. Kerr on 'Natural Lighting,' and the remarks of the several speakers in the ensuing discussion. Another engagement prevented my attending the adjourned discussion at the kind invitation of your Hon. Secretary, but I should like to add that the Society is to be congratulated in promoting discussion on such a vitally important matter as the subject of school lighting—particularly natural lighting—by such eminent hygienists.

As one who has given a deal of study to matters of school hygiene, especially lighting and ventilation, and its bearing on school planning, I am struck by the better provisions which exist between the arrangements for lighting in the schools of foreign countries and those obtaining in this country. We are indebted to Continental nations for many improved methods of education and advanced ideas as to hygiene, and to Germany in particular for the institution of medical inspection of scholars and school buildings; but of such experience advantage has not been taken by those whose duties are connected with school planning to profit thereby in respect to the provision of better natural lighting. Thus English schools have not benefited by these researches.

School planning is now receiving attention and some development in parts of the country, mainly owing to the energies of School Medical Officers whose duties are, more or less, connected with remedial measures for defects in old schools and suggesting improvements in the design of new buildings in matters relating to the hygiene of the child. This development so far has been mainly in the direction of securing a better means of ventilation by windows, and from which the equally important matter of natural lighting is inseparable.

The generally accepted rule of the window glass area in relation to the floor area being as 1 : 5, as applied to English classrooms, does not give efficient light to certain of the classroom desks. This rule, undoubtedly emanating from those Continental hygienists and specialists acting in conjunction with school architects, for many years has been applied to classrooms under different conditions, *i.e.*, to classrooms containing three rows of dual desks in width, as against the four or five rows customary in this country. The intensity of the light on an object varying inversely as the square of its distance from the luminous source, it will be seen how inefficiently lighted those desks placed next to the corridor wall side of a classroom —say 25 ft. in width—will be in comparison to those nearer windows. This deficiency has been overcome to some extent by supplementary right-hand lighting by borrowed lights, which in my opinion does not supply that quality of light necessary for efficient study, and which on dull days is practically valueless. Not only is there a loss of light by reflection which might otherwise be obtained from lightly and suitably coloured opposite walls, but, moreover, these supplementary windows are partly contributable to the result of "noisy schools."

The shape of the classroom, which has such an important bearing on lighting, in English schools approximates a square, whilst those of other countries being rectangular in shape, the longer side is placed next the external and corridor walls. The

difference in this respect between English schools and those of practically all other countries in the world is striking and convincing. In a paper on 'School Planning' I had the honour to read at the 25th Annual Congress of the Royal Sanitary Institute held at Brighton last year, it was my privilege to deal with the foregoing subject as well as that of the bilateral natural lighting of classrooms.

Cross or through ventilation has introduced another factor into designs of schools, a factor presumably overlooked by those advocates for its advantages. I quote the following from the paper on the subject of bilateral direct lighting :—

"The introduction of cross ventilation by bilateral windows for direct lighting, as in the case of the Derbyshire and Staffordshire schools, however, produces another evil, and Dr. Liebreich, an eminent school hygienist, has rejected this method of lighting since 1874. This view is more recently shared by Dr. A. Coombe, School Medical Officer of Lausanne, Switzerland, for the following reasons : One side of an object is more strongly lighted than the other according to the relative distance at which it is placed from the opposite windows, with the result that the shadows are more or less accentuated, and the appearance of the object may be constantly changing. The eye, attracted by two conflicting lights, seeks to avoid the brighter light on one side of the object, but finds on the opposite side a light varying in intensity, thereby inducing constant fatigue which is likely to result in myopia."

The various regulations as to school buildings in Switzerland stipulate that the anterior windows should not serve for lighting the class-rooms, and this appears to be the general practice in all other countries.

My apology for the length of this communication is the vital importance of lighting, and its influence on future development in school planning.

Acceptance of Hon. Membership in the Illuminating Engineering Society by Dr. A. Moeller.

It will be recalled that, subsequent to the visit of the delegates of the Society to the Second Congrès International des Maladies Professionnelles at Brussels last year, it was unanimously resolved to nominate Dr. A. Moeller, the distinguished President of the Congress (also President of the Académie Royale de Médecine and Member of the Commission des Accidents du Travail, &c.), an Hon. Member of the Illuminating Engineering Society. An announcement to this effect was made at the first meeting of the Society on Nov. 8th, 1910.

It will doubtless be of interest to members to be acquainted with Dr. Moeller's letter kindly consenting to accept nomination. This is as follows :

To the Hon. Secretary of the Illuminating Engineering Society.

Dear Sir,—I beg to acknowledge your letter of Jan. 3rd, informing me that the Illuminating Engineering Society has conferred upon me the title of Honorary Member. I highly appreciate this flattering distinction, and desire you to convey to your colleagues my thanks for the honour done me.

Believe me,

Yours very sincerely,

Dr. A. Moeller.

It need not be said that the Society on its part values very highly the privilege of numbering Dr. Moeller among its honorary members. The question of conditions of illumination in factories is now receiving close attention in many countries, and co-operation between our Society and those on the Continent who are considering similar problems should do much to improve the existing conditions.

Notes on Some Gas-Lighted Schools.

(*Communicated by* Mr. F. W. Goodenough.)

Classrooms.

In most cases the minimum illumination was satisfactory.

In the case of one of the classrooms at the Millbank School, where a minimum desk illumination of only 1·4 foot-candles was found, the desks are arranged in steep tiers. The minimum was found upon the desks in the rear corners of the classroom. Notwithstanding this, the gas consumption per square foot was very high, indicating that the arrangement of the lighting, *i.e.*, four two-light "C" burner pendants, was capable of great improvement, both in regard to illumination and economy.

The experiments made in the class-rooms at the Westminster City School show the superior economy of the inverted system of gas lighting. This is also confirmed by the experiments made at East Ham.

ILLUMINATION OF CLASS-ROOMS.

School.	Area of floor, sq. ft.	Accommodation. Desks.	Accommodation. Scholars.	System of lighting.	Gas consumption, cubic ft. per burner.	Illumination of Desks. Foot candles. Max.	Min.	Average	Black-board.	Diversity co-efficient.	Gas consumption, cub. ft. per hour per 100 sq. ft. of floor.
L.C.C. School, Thornhill Rd., Barnsbury, N.	750	42	84	Upright incandescent gas, squat shades	21	3·2	2·1	2·61	1·9	1·52	2·8
	540	30	60	" "	14	4·1	2.4	3·12	2·0	1·71	2·6
Westminster City School, Palace St., S.W.	520	16	31	Inverted burners, frosted globes and opal shades	12	5·5	2·4	3·74	5·8	2·29	2·31
	520	18	34	" "	8	4·0	1·6	2·36	1·5	2 50	1·54
	490	27	27	Upright burners, opal shades	16	3 0	2·4	2·70	2·8	1·25	3·27
East Ham Sch., Hartley Avenue, E. Ham, E.	730	16	60	Inverted lamps with white enamelled shades	15	4·8	2 3	3·1	2·5	2·09	2·06
	634	15	50	" "	15	6·0	2·4	4·21	2·6	2·5	2·37
L.C.C. School, Ebury Bridge, S.W.	574	28	56	Upright burners with "reflex" shades	21	4·6	2·6	3 74	3·0	1·77	3·36
	492	24	48	Upright burners with the new type of shade	17	7·2	4·0	5·44	1·5	1·8	3·46
L.C.S. School, Millbank, S.W.	580	30	60	Upright burners with new type of shade	32	4·7	2·1	3·39	1 9	2·24	5·51
	606	30	0	" "	32	3·7	1·4	2·84	2·1	2·64	5·2
Westminster City School, S.W.	520	16	31	Inverted burners with frosted globes and opal shades	12	7·7	1·6	3·35	4·7	4·81	2·31
	520	16	31	Inverted burners but with flatter shades and with burners 9 ft. instead of 7 ft. 9 in. from floor	12	5·5	2·4	3·74	5·8	2·29	2·31

Note.—All the observations were made on the writing surface of the desk.

The following figures are interesting as showing how the illumination of a class-room may be improved by a re-arrangement of the existing lights.

FIG. 1.—Westminster City School, Art Room. Inverted Burners. Illumination 6·15 foot-candles.

FIG. 2.—Westminster City School, Gymnasium. Illumination on Floor 2·3 foot-candles.

As bearing on the question of shades the data obtained at Ebury Bridge are interesting. Two rooms were examined. The larger room (574 sq. ft.) was lighted by upright burners with "Reflex" shades, while the small room was lighted by similar burners fitted although the desk illumination was satisfactory in each case. This would indicate the need for special provision being made for the lighting of blackboards, and, as it would be quite an inexpensive item, it certainly should be done.

ILLUMINATION OF SPECIAL ROOMS AT THE WESTMINSTER CITY SCHOOL.

Description of Room.	Floor Area.	Accommodation.	System of lighting.	Gas consumption, cubic ft. per hour.	Illumination, Foot candles.			Diversity co-efficient.	Gas used per hour per 100 sq. ft. of floor.
					Max.	Min.	Average		
Art Room	1145	—	Inverted lamps and burners with opal shades	52	15·0	6·0	—	—	—
Chemical Laboratory	765	34	Inverted burners and opal shades	26·0	3·9	2·9	3·4	1·35	3·4

ILLUMINATION OF SCHOOL WORKSHOPS.

School.	Floor area, sq. ft.	Accommodation.		System of lighting.	Gas consumption, cub. ft. per hour.	Illumination of benches. Foot candles.			Diversity co-efficient.	Gas used per hour per 100 sq. ft. of floor.
		Benches.	Scholars.			Max.	Min.	Average		
Westminster City School, S.W.	1270	15	30	Inverted burners with opal shades	48	5·4	3·6	4·5	1·5	3·78
L.C.C. School, Barnsbury, N.	957	16	32	Upright burners with new type of shade	56	5·0	4·0	4·4	1·25	5·85

NOTE.—The observations were made on the horizontal surface of the benches.

ILLUMINATION OF SCHOOL HALLS.

School.	Floor area, sq. ft.	System of lighting.	Gas consumption, cub. ft. per hour.	Illumination of floor. Foot candles.			Diversity co-efficient.	Gas used per hour per 100 sq. ft. of floor.
				Max.	Min.	Average.		
L.C.C. School, Thornhill Rd., Barnsbury, N.	2310	Upright burners with new No. 3 shade.	35	2·4	2·0	2·25	1·2	1·52
L.C.C. School, Ebury Bridge, S.W.	1414	Upright burners arranged in 3-light clusters.	81	4·3	3·1	3·84	1·39	5·73
East Ham School, Hartley Avenue, E.	2565	Inverted lamps with white enamelled shades.	49	3·4	2·4	2·9	1·42	1 91
Westminster City School, S.W.	2755	Inverted system, various, see photograph.	91	2·4	2·0	2·3	1 20	3·30

with the new shade described by Dr. Bishop Harman in his paper. The superiority of the new shade is clearly shown in the results obtained.

In regard to the illumination of blackboards, this was found to be low in two cases, *i.e.*, 1·5 foot-candles,

SCHOOL WORKSHOPS.

Two workshops were visited, both of which are used for instruction in wood-work.

On referring to the summary, it will be seen that although the illumina-

tion of the benches was practically the same in each case, there was a considerable economy in favour of the inverted system. The gas consumption per 100 sq. ft. was 3·78 cubic feet per hour for the inverted and 5·85 cubic feet per hour for the upright system.

The illumination that was found, *i.e.*, 4½ foot-candles, appeared quite sufficient for the kind of work carried on.

School Halls.

This is a feature common to most schools. Three halls were visited, and the results of the observations made are included in the summary.

The gas consumption at Ebury Bridge was somewhat high, indicating the unsuitability of the fixture used there.

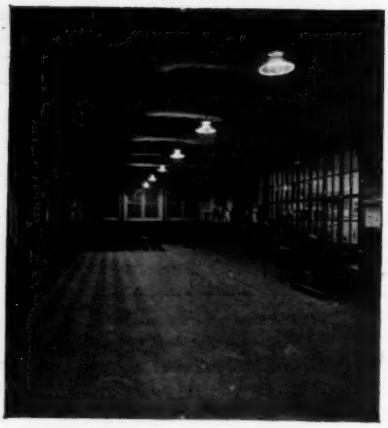


Fig. 4.—East Ham, School Hall. Illumination 2·9 foot-candles.

Fig. 3.—Barnsbury (L.C.C.) Typical Classroom: 2·25 foot-candles on desks.

Reading *versus* Writing Surface.

The desks used in the L.C.C. schools are fitted with turn-up fronts, thus forming two distinct surfaces, *i.e.*, the writing and reading surfaces. It is interesting to compare the illumination of the two surfaces.

In a particular case the following results were obtained :—

Illumination in Foot-Candles.			
Writing Surface.		Reading Surface.	
5·1	4·0	5·7	4·4
5·5	4·9	5·7	4·5
7·2	5·6	6·6	5·0
6·8	5·4	6·4	4·8
6·4	5·1	5·0	3·8
4·8	4·5	2·7	2·6

The first and third and second and fourth columns refer to identical desks.

Institution of Sanitary Engineers.

Coming Lecture on Illumination.

The Institution of Sanitary Engineers beg to announce that a lecture on the **'Hygienic Aspects of Illumination and the Progress in Illuminating Engineering'** will be delivered by Mr. Leon Gaster, on **Monday, April 10th, 1911**, at 120, Victoria Street, Westminster, S.W. The chair will be taken by the President, Mr. A. J. Martin, M.Inst.C.E., F.G.S.

Members of the Illuminating Engineering Society will be welcomed.

Some Remarks on the Measurement of Diffuse Daylight in Classrooms.

By Prof. Leonhard Weber (Kiel).

In 1882 my friend and colleague Hermann Cohn in Breslau requested me to work out for him a method by which he would be enabled to measure exactly the amount of diffuse daylight.

In the state of photometry at that time it was not at all clear at first how this problem was to be met. One could—for instance—have aimed at assembling and measuring the whole amount of light, which is projected from all directions on the surface of a small ball, placed on the spot (P) to be examined. Or the attempt could be made, to state in some suitable way the "intrinsic brilliancy" of all surfaces of the walls and windows which could be seen from P. The method which I chose then, and which was the only one used at that time, was, however, different from this.

As is well known, this method consists in arranging a plane surface in numerous positions and measuring in each case the illumination ("indikierte Helligheit" as I called it then). *One* value of illumination which is of a special practical interest is that measured in the horizontal position or in the position parallel to the plane of the desks. Such measurements of diffuse daylight were subsequently confined to this one position. They have been carried out by means of the special form of *milk-glass* photometer, constructed by me. As the unit of intrinsic brilliancy I proposed the "meter candle," meaning by this a unit similar to the unit of illumination derived from the candle in the well-known way, and often called "lux," (but without sufficient reason).

In daylight, the measured amount B depends upon the intrinsic brilliancy of the sky opposite to the window, the solid angle w which encloses the area of sky seen from P, the angle at which these direct rays of light enter the room, and upon the qualities of the interior as regards reflection from the walls and ceiling, &c. There is a well-known relation $B=R.H$, where H denotes the brilliancy of the sky in secondary units* and R is a coefficient based upon the influence of the angle and the reflected light from the walls, as referred to above.

Of these three factors B, R, and H, H is changing every moment; but it will be possible to find for H average values for each day and each hour. In Kiel this has been partly effected already. The coefficient R characterizes a distinct spot in a distinct room, which is situated in a distinct position relative to the meridian. R is, for each spot, almost a constant figure. It is influenced, however, to some extent, though not very appreciably, by the height of the sun above the horizon Generally speaking, B, like H, is constantly changing.

Hermann Cohn, not being satisfied by the hazardous measurement of a few figures of B, I proposed to him to specify the coefficient R, as characterizing the qualities of each spot as regards access of daylight. This was carried out by the stereogoniometer†, which was considerably improved a few years ago by Mr. Moritz.

The stereogoniometer takes into account the main part of the coefficient R, as the effect of the diffuse reflected light from the walls is relatively small. But, nevertheless, such reflection is of

* The meaning of the primary and secondary units used in this connexion has been previously explained in this journal. See *Illum. Eng.* vol. ii., Feb., 1910, p. 116.

One secondary unit, as thus defined, represents the degree of intrinsic brilliancy of a white matt surface, of albedo unity, which receives an intensity of illumination of one metre-candle.

† Mentioned by Dr. Kerr, *Illum. Eng.* March, 1911, p. 154.

some consequence in the case of those seats in a school class, which are most remotely situated from the windows. For this reason, mere measurement of the solid angle of sky alone was deemed insufficient.

A short time ago Dr. Thorner constructed a very handy and ingenious apparatus, by which the quotient B or R could be found. This apparatus has been judged to be "very neat and convenient" by Dr. James Kerr in his lecture of the 16th of February (*Ill. Eng.*, vol. iv. No. 3, March, 1911, p. 154).

It is possible to ascertain by means of this apparatus whether the factor R for a certain spot exceeds or is less than a certain average value. This latter, for instance, might correspond to a solid sky-angle of 50 degrees.

The improvement of the Thorner apparatus by the addition of a measurable Iris-stop makes it a real measuring instrument for the deciding coefficient R.

Hereby the problem of the measurement of diffuse daylight is reduced to finding (1) R and (2) H. Pre-supposing a knowledge of the average change of H in the course of the day and of the year, it is clear that knowing R we can tell the average illumination of the examined spot for every hour and for every day.

The little Thorner apparatus has one drawback. The instrument itself, and still more the head of the observer, may obstruct a considerable percentage of the light, which ought to reach the white test-plate. For this reason, I devised a modified form of the instrument (Fig. 1), and had this constructed by Messrs. Franz Schmidt & Haensch in Berlin.

FIG. 1.

On the left is a box covered with a plate of milk glass (see Fig. 2), and containing a mirror, inclined at 45 degrees. The plate, the position of which is adjustable, receives the whole available diffused illumination. In the middle of the long tube a plaster of Paris plate (G), also having an inclination of 45 degrees, is arranged; on this the lens of the side-tube projects an image of the sky. The observer looks through the aperture in this plate at the surface, and adjusts the brightness of G by contracting the Iris-stop in the side tube until equality between the two plates is secured. The position of the Iris-stop can be read off on a scale and the required figure R is subsequently obtained by the help of an empirically found curve of calibration.

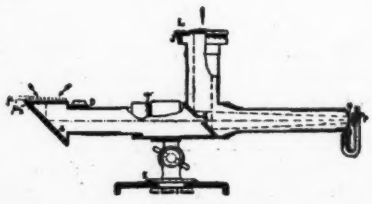


FIG. 2.

It might be mentioned that this instrument can be also used for various other measurements of illumination. For instance, the relative brightness of different spots on the sky, the zenith taken as standard basis, might be ascertained. Also, it is possible to measure the vertical illumination in the N., S., E., and W. directions. The scope of measurement can be extended by closing the side tube with an obscuring and diffusing glass.

In all cases this photometer gives *relative* figures, and compares the incident light on the plate with that coming through the lens in the side tube. Therefore I have called this instrument the "Relative-Photometer," in order to distinguish it from the Thorner Light-tester (Lichtprüfer).

Its advantages are (1) that there is no darkening by the head of the observer, (2) that the measurement of the illumination is effected according to the best principle of inserting

obscuring and diffusing plates of glass. The transmitted light of these glass plates is a more exact measure of the intensity of light than the reflected light of the best plaster of Paris surfaces.*

Library Lighting—Discussion.

(*Continued from p. 152.*)

MR. L. B. MARKS, NEW YORK (*communicated*) :—My views on the lighting of moderate size public libraries, such as the Carnegie buildings in New York, were published in *The Illuminating Engineer*, London, in a paper by me entitled 'Design of the Illumination of the New York City Carnegie Libraries,' vol. i. 1908, pp. 921–932 inclusive and pp. 1009–1018 inclusive. The lighting of a large number of public libraries located in different cities of the United States has been modelled after the layout designed by me and fully described in the paper above referred to.

In the larger public libraries, one of the important problems to consider is the illumination of the stack room. In this connexion it may be of interest to mention that we designed the recently completed lighting installation for the new stack room of the Library of Congress, Washington, D.C. This stack-room has ten decks and houses more than 1,000,000 books.

I am sending you herewith a photograph of the Library of Congress and a plan showing the typical layout for the lighting of the new stack-room. This plan is drawn to scale. You will note that the book stacks are about 34 ft. long by 3 ft. 6 in. wide, and that the depth of the aisles between the stacks is 3 ft. 6 in. The ceiling height of each deck is only 7 ft. in the clear.

Library of Congress, Washington, D.C.

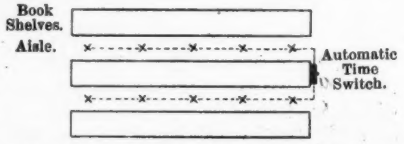
In each aisle at the ceiling there are provided five 40-watt bowl frosted tungsten lamps symmetrically spaced about 7 ft. apart as shown on the plan. Each of these lamps is to be equipped with a prismatic reflector having two opposite quadrants heavily enamelled

* (c.f. Fritz Thaler: Die diffuse Reflexion des Lichtes an matten Oberflächen) Dissertation Kiel, 1893.

inside and outside, the other two quadrants being clear prismatic glass. The reflectors are to be so mounted that the enamelled quadrants will face the book shelves and the clear glass quadrants will be in line with the axis of the aisle between the book shelves. By this design, substantially uniform illumination is obtained over the entire face of the book backs, the illumination of the bottom row of books being practically the same as that of the top row.

From the standpoint of economy, a very important consideration in the design of the lighting of an installation of this character, is the switching arrangement provided. We found after an extended examination in the Library of Congress, that thousands of dollars in cost of lighting might be saved if suitable provision were made for automatically switching the lamps out of circuit when the light was not needed. This examination revealed that the library attendants usually spend six to seven minutes in collecting books from a certain section of the stack, after which time they may not return to the particular stack in question for a considerable period. It was found further that with the system of manually controlled switches which had been installed in the old stack, the lights were rarely turned off by the attendants, except at the closing hour.

An automatic time switch was therefore designed by us and installed in the new stack-room. As shown on the plan, each of these time switches con-



Plan of lighting the stock room of the new wing of the Library of Congress, Washington, D.C. This stock room has ten decks which house 1,000,000 books. Scale—$\frac{1}{8}$ in.=1 ft.

trols ten lights located in contiguous aisles. On the ten decks of the building, a total of 216 automatic time switches have been installed. The time switch is provided with a push button which the attendant pushes to light the lamps on entering the stack. The switch automatically extinguishes the lamps after a period of ten minutes, thus usually allowing a margin of a few minutes lighting after the attendant has left the stack.

Provision is also made in each switch for the insertion of a key for cutting out the time limit device, thus leaving the stack circuit under manual control if desired.

Efficiency of Glow-Lamps on Direct and Alternating Current.

THE experimental results so far obtained in comparing glow-lamps working on direct and alternating current are not conclusive, and it is of interest to note that Mr. E. J. Edwards, writing in *The Electrical World*, describes a mathematical investigation of the subject. As the result of his calculations Mr. Edwards obtains a measure of the comparative efficiencies on direct and alternating current, and finds that this is usually very near unity under all practical conditions, but slightly in favour of alternating current. The difference is so small that it would be difficult to obtain any evidence by direct photometric test. An example worked out by the author shows the ratio to be 0·9943 for a 25-watt tungsten lamp working at 25 cycles on an approximate sine wave.

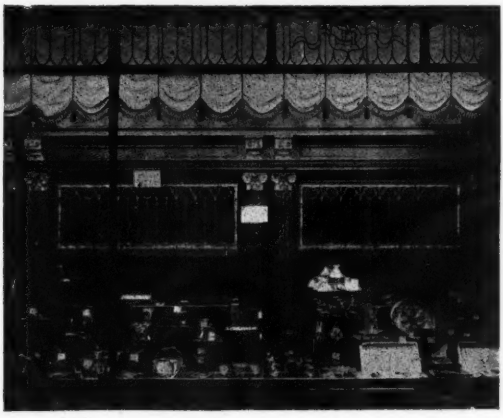
The effect on life has also been worked out mathematically, and the author proposes to examine the effect of wave-form, but he anticipates that this will also be of a very small order.

Short Notes on Illuminating Engineering.

From all Sources.

A Well-Lighted Shop Window.

THE shop window illustrated here is a good example of the value of a carefully-designed scheme of illumination for displaying goods to the best advantage. The effect is largely due to the use of Holophane reflectors by which a uniform distribution of light is obtained, and the effective screening of the upper part of the window so that none of the light sources are visible, is an important feature. It should be noticed that by using reflectors which are not opaque, some amount of light is allowed to illuminate the upper curtains and the name scroll on the glass at the top of the window, and at the same time a sharp contrast between the brightly lighted goods and the dark upper portion is avoided.



Charges for Shop Window Lighting.

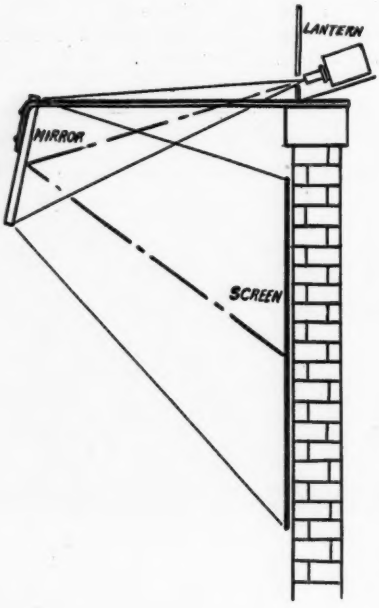
AN interesting development in systems of charging for shop window lighting is taking place in many American cities, according to a recent number of *The Electrical World*. The idea is to charge a fixed sum per month, according to the number of lamps installed, and in the majority of cases time switches are employed to control the time during which the lamps are lighted. These switches are usually rented from the supply company, and in many cases the lamps also, with shades and holders, are rented. The contract frequently includes cleaning of the fixtures and renewal of lamps that are burnt out, or blackened so as to materially reduce the candle-power.

A typical store, with windows lighted by eight 40-watt tungsten lamps, would cost the owner about 12*l.* 10*s.* per annum, including renewals and time switch.

Lantern Pictures for Advertising.

A NOVEL method of throwing pictures or other matter on a screen is shown in the accompanying sketch, and was described in *The Electrical World* recently. It has some interesting features which distinguish it from the usual plan of illuminating the screen from behind.

The screen is fixed on a wall and illuminated by the rays reflected from a mirror mounted several feet from the building and above the screen. The image is projected on to this mirror



by the lantern, which is fixed behind a small opening in the wall. By this arrangement, there is no necessity to have a large window opening the full size of the screen, nor is it necessary to occupy much room space as is the case when the lantern is mounted behind the screen. The distortion that would result from the rays striking the screen obliquely can be corrected by arranging the slide in the lantern at such an angle as to bring it parallel to the plane of the screen.

Lamp-Makers and Distribution Curves.

FOR some time past it has been the practice of many lamp manufacturers in America to print in their catalogues, side by side with the illustration of a particular lamp, a polar curve showing the distribution of light obtained from it in a vertical plane.

Mr. J. G. Clark, writing in *The Journal of Gas Lighting*, March 14th, asks whether it is not time that makers of gas-lamps in this country adopted similar methods. He says :—

"Much ingenuity has been displayed by the manufacturers in producing lamps for specific purposes—*i.e.*, to arrange the parts so as to secure various illuminating effects. But when a question arises as to what type of lamp would be suitable for a specific purpose, one looks in vain in the catalogues for the necessary information....A complete polar curve, showing the vertical distribution of the light given by the lamp, should be included in the maker's catalogues, so that a prospective purchaser could readily ascertain which pattern would be most suitable for his purpose....and, seeing that reliable photometric appliances are now available, there appears no reason why the information should not be given."

Rating of Street Lamps.

A CORRESPONDONT writing on the above subject in *The Electrical World* draws attention to the fluctuations in candle-power of arc lamps. He puts in a plea for considering the minimum candle-power given by an arc-lamp at any particular angle, as well as the average illumination. He points out that as the candle-power varies through such a large range, even in the same direction, a comparison between the average value of an arc lamp, and that of a tungsten lamp, for example, is apt to be misleading. This minimum value of the illumination, it is contended, is of the greatest importance in street lighting, and is not sufficiently taken into account when arc lamps are rated on a basis of average illumination only.

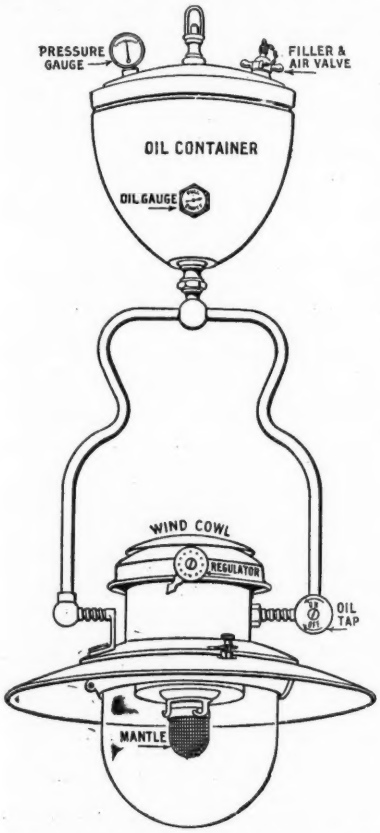
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

An Incandescent Oil-Lamp for School Lighting.

An interesting point raised in Dr. Harman's paper before the Illuminating Engineering Society on 'Artificial School-Lighting' was the question of the best means of lighting schools in remote country districts. Oil-lamps are frequently employed, but it may be presumed that the standard of illumination, with old-fashioned wick lamps, may fall considerably below that considered desirable with gas and electricity.



Some particulars of the Blanchard incandescent oil-lamp, which we have received from **The Gas Economizing and Improved Lamp Syndicate** should therefore be of interest. This lamp utilizes paraffin vapour and an inverted incandescent mantle, and is claimed to give a vastly more powerful light than the oil lamps of the past.

The working of the lamp will be understood from the figure.

The oil container is filled with paraffin until the gauge needle stands at "Full"; air is pumped in until a suitable pressure is reached, and the lamp is then lighted by a spirit-burning device.

From this time onwards the lamp burns quite automatically: its own heat and the pressure of air in the container keep a constant stream of gaseous paraffin flowing into the burner, and a steady and brilliant light, very different from the smoky and unsteady flames from the older types of oil-lamps, is obtained.

Among the chief advantages claimed for this lamp are:—

(1) It is self-contained and portable: its position can be readjusted at will, and it can be hung wherever it is most needed.

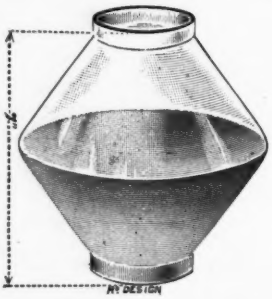
(2) A powerful light is secured, candle-powers from 75 up to 1,000 according to the consumption being obtained.

(3) The light is steady and free from any tendency to flicker or smoke: these qualities of cleanliness and steadiness render it particularly suitable for school lighting.

(4) Economy: according to the claims of the Blanchard system a low quality of paraffin can be used, and one gallon of this oil will give an illuminating capacity of 18,000 hours.

Opal Globes for School Lighting.

WE have received from **Messrs. A. E. Podmore & Co.** (34, Charles Street, Hatton Garden, E.C.) some particulars of GLOBES which they have brought out specially FOR USE IN SCHOOLS. The example shown in the accompanying illustration is for upright burners, but a similar type is manufactured for use with inverted burners. In each case the globes are reversible, so that the opal part can be used either at top or bottom, but we understand that for school lighting the opal is placed at the bottom to protect the eyes of the children from the glare of the direct rays, and also to throw the light on to the ceiling, thus gaining the advantages of indirect lighting.



Holophane "Residence" Reflectors.

THE reflector which we illustrate here is a typical example of the NEW "RESIDENCE" LINE OF HOLOPHANE REFLECTORS which, we understand, **Messrs. Holophane Ltd.** (12, Carteret Street, Queen Anne's Gate, S.W.), are now in a position to supply to the trade.

They are stated to maintain the scientific design and control of the light rays characteristic of Holophane; at the same time these possess artistic qualities which should make them specially serviceable for interior lighting in residences, for which, as the name implies, they have been specially designed.

Tests on Metallic Filament Lamps.

WE have received from Mr. Lancelot Wild particulars of a series of tests carried out by the **Westminster Testing Laboratory** (York Street, Westminster, London, S.W.) on fifteen of the chief makes of metal filament electric lamps as follows: Aegma, "Z," Welsbach, Sunbeam, Metalik, Stearn, Auriga, Osram, Ediswan, Cryselco, Pope, E.M.F., Mazda, Metalite, and Rugby.

Life and efficiency tests of these lamps were carried out on a regulated 200-volt circuit for a period of 2,000 hours, the mean horizontal c.-p., watts, and efficiency being measured every 200 hours in the course of the test.

It is interesting to observe the variety of metallic filament lamps now available in this country, and it is therefore naturally a matter of some moment to distinguish the best types. It may be added that the published results of these tests show that considerable deviations in rated candle-power, efficiency, and life exist on the part of different classes of lamps.

The complete results of these investigations have been printed in full and bound in leather, and can be purchased at the subscription charge of 2*l.* 12*s.* 6*d.*; additional copies can be procured (for personal use only) at £1 1*s.* each.

Tantalum Lamps for Traction Work.

THE General manager of a tramway company has written the following letter to **Messrs. Siemens Brothers Dynamo Works, Ltd.** (Tyssen Street, Dalston, N.E.):—

"DEAR SIRS,—In reply to yours *re* the 'TANTALUM' LAMPS supplied to us for TRACTION PURPOSES, a sample batch were placed in Car No. . . on the 21st of February, 1910. They have run up to the present 11,870 miles. There has only been one breakage, which took place during the first week the lamps were running. This was a broken globe, not a broken filament. The lamps appear to be still in very good condition, and in view of this test there is no question about them standing up to their work. Would you like us to return these lamps to you or to leave them in the car and run them to destruction."

It would be of interest to know how long the lamps will have to be run before their destruction is accomplished, and we understand that Messrs. Siemens Bros. expect to be able to give particulars on this point at some later date.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

There are again many items of interest in United States journals, notably A. E. KENELLY'S presidential address to the Illuminating Engineering Society (*T.I.E.S.*, Feb.), on **The Profession of Illuminating Engineering**; a paper by F. J. PEARSON tracing the growth of the American Illuminating Society (*Elec. World*, N.Y., Feb. 23) is also opportune. P. F. BAUDER deals with **Reflection Coefficients.** Special consideration is given to colour, illumination in different interiors is plotted out, and a table of absorptions of various globes is presented.

The first number of the new volume of the *Illuminating Engineer* (New York) contains a summary of **Illuminating Engineering Progress during 1910**; other articles deal with the lighting of a church choir, a large power house, &c.

G. B. MUTH (*Am. Gaslight Jour.*, Feb. 27) experiments on the kind of light for cinematograph film-making; a combination of arc-lamps and mercury lamps is preferred. IVES (*Phys. Rev.*, March, 1911) discusses Crova's method in photometry; he finds that it only answers exactly for incandescent spectra, and that the best ray to select is not always that characteristic of the maximum sensibility of the eye. The same author and LUCKIESCH (*Elec. World*, Feb. 16) also describe a **New Method of Testing Intrinsic Brilliancy** (see p. 202 in this number).

Several other articles discuss the ratings of street lamps and the possibility of framing a standard specification.

ELECTRIC LIGHTING.

A. BOJE contributes a well illustrated and full account of tests of **Illumination for Dock Yards, Piers**, &c. (*E.T.Z.*, March 23). Full tables of illumination, data, and costs are given. An interesting attempt is made to show distribution of illumination over an area by actual models to scale.

E. E. EDWARDS (*Elec. World*, Feb. 16) mathematically demonstrates that similar results as regards life and efficiency should be obtained by direct and alternating current. G. LEIMBACH (*E.T.Z.*, March 16) discusses the radiant efficiency of glow-lamps, which he finds to be well within 5 per cent, 95 per cent of energy being wasted.

H. T. OWENS (*Elec. Rev.*, N.Y., Feb. 25) emphasizes the value of **Flame Arcs outside Shops**, for bill boards, &c., and for advertising purposes expressing his view by saying that "light holds the trade." The same journal (March 4) describes a long burning flame arc which will burn for 100 to 200 hours without recarboning.

GAS, OIL, ACETYLENE LIGHTING, &c.

Several articles have dealt with the **Street Lighting Specification**: thus R. WATSON (*J.G.L.*, Feb. 28) points out the care needed to draft a specification suitable for different localities.

The Journal of Gaslighting deals with **Railway Carriage Lighting**, relative costs of gas and electricity being presented. While the illuminating value of ordinary gas soon falls under compression, **Calorific Value** is much less affected. Hence the value of the incandescent mantle. Inverted mantles break less easily than vertical ones. On main lines they are renewed usually every 2 months, on suburban lines every 5 weeks on account of the greater jar. 8 or 20 inches of pressure are often used, and 30 c.-p. units preferred.

The *Rev. des Éclairages* has an interesting comparison of the costs of various **Systems of Lighting for Cinematographs**; reference is also made to recent regulations of the Parisian police giving preference to dissolved acetylene as a safe illuminant in certain classes of interiors.

ILLUMINATION AND PHOTOMETRY.

Ashe, S. W. The Proper Basis of Comparing Illuminants (*Elec. World*, N.Y., March 2).
Bauder, P. F. Reflection Coefficients (*T.I.E.S.*, Feb. 19).
Cravath, J. R. Illumination Problems in Small Cities (*Elec. Rev.*, N.Y., Feb. 25).
Editorial. Streetlighting Contracts (*G.W.*, March 18).
Elliott, E. L. A Year's Progress in Illuminating Engineering (*Illum. Eng.*, N.Y., March).
Ely, R. B. A Method of Illuminating a Church Choir (*Illum. Eng.*, N.Y., March).
Evans, W. A. D. Lighting a Large Power House (*Illum. Eng.*, N.Y., March).
Ives, H. E. Note on Crova's Method of Heterochromatic Photometry (*Phys. Rev.*, March, 1911).
Ives, H. E., and Luckiesch, M. A New Method of Measuring Intrinsic Brilliancy (*Elec. World*, Feb. 16).
Kenelly, A. E. The Profession of Illuminating Engineering (*T.I.E.S.*, Feb.).
Muth, G. B. Artificial Light *v.* Sunlight for the Making of Moving Picture Films (*Am. Gaslight Jour.*, Feb. 27).
Pearson, F. J. The Illuminating Engineering Society, its Origin, Scope, and Future (*Elec. World*, N.Y., Feb. 23).
Spillman, H. C. The Illumination of a Modern Factory (*Elec. World*, N.Y., Feb. 23).
Tremaine, C. L. Streetlamp Ratings (*Elec. World*, N.Y., Feb. 23).
Illumination of Schools (Discussion at a meeting of the Illuminating Engineering Society, Feb. 16, March 16; *J.G.L.*, March 21; *G.W.*, March 18; *Electrician*, March 19, &c.).
Central Station Lectures on Illumination (*Elec. World*, N.Y., Feb. 23).

ELECTRIC LIGHTING.

Boje, A. Elektrische Beleuchtung von Kaischuppen (*E.T.Z.*, March 23).
Davis, F. K. British Practice in the Conversion of Street Gas Lanterns (*Elec. Rev.*, N.Y., Feb. 18).
Editorial. The Growth of the National Electric Light Association, Flaming Arcs, &c. (*Elec. Rev.*, N.Y., Feb. 18).
Edwards, E. E. Efficiency of Glowlamps on Direct and Alternating Current (*Elec. World*, N.Y., Feb. 16).
Griffin, G. B. Progress in Electric Lighting during 1910 (*Illum. Eng.*, N.Y., March).
Harrison, Haydn T. Streetlighting by Modern Electric Lamps (*Jour. Inst. of E.E.* (London), Feb., 1911).
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GAS, OIL, ACETYLENE LIGHTING, &c.

Böhm, C. R. Die pyphoren Metalle und ihre Bedeutung für die modernen Feuerzeuge (*Z. f. B.*, Feb. 28).
Broadberry, A. E. High Pressure Shoplighting (Discussion, *J. G. L.*, March 14).
Clark, J. G. Distribution Curves of Street Lamps (*J. G. L.*, March 14).
Editorial. Coal Gas for Train Lighting (*J. G. L.*, Feb. 28).
High-Pressure Shoplighting (*J.G.L.*, March 14).
Eisele, W. Die Zukunft des Leuchtgases (*J. f. G.*, March 11).
Scott Snell, E. Theory and Practice of Petrol Air Gas (*G.W.*, March 11).
Watson, R. Presidential Address before the Manchester District Institution of Gas Engineers (*J.G.L.*, Feb. 28; *G.W.*, March 4).
Gas Lighting for Railway Carriages (*J.G.L.*, Feb. 28, March 7).
L'Eclairage des Fêtes Foraines (*Rev. des Eclairages*, March 15).
Le Prix de Revient des Eclairages pour la Projection et le Cinematographe (*Rev. des Eclairages*, March 15).
The Amber Light Campaign, in Chicago (*Am. Gaslight Jour.*, March 13).
Neue Hangegaslampe (*J. f. G.*, Feb. 25).
Moderne Gasbeleuchtungs gegenstände (*J. f. G.*, March 4).
Neuere Verfahren zur Herstellung von Gasgluhkörpern (*Z. f. B.*, Feb. 28).

REVIEWS OF BOOKS.

Electric Wiring, Fittings, Switches, and Lamps. By W. Perren Maycock, M.I.E.E. (Whittaker & Co., 2, White Hart Street, Paternoster Square, London, E.C.) 6s. net.

THE fourth edition of this well-known work opens with a chapter explaining the main principles of the supply and distribution of electricity for different purposes. In describing the chief systems of distribution, the author lays stress on the importance of flexibility of design in house wiring, and explains the necessity of introducing and carefully supervising fuses and other protective devices. The use of S.P., D.P., and quick-break switches is also discussed.

Chap. ii. deals with switches in greater detail, and traces the lamp circuit from the fuse board onwards, showing connexions to ceiling-roses, plugs, &c. Methods of two-way switching are fully illustrated.

Detail specifications for house and other installations are dealt with at the

beginning of chap. iii., and several typical examples are presented and discussed from the wireman's point of view, followed by a tabulated classification of various types of incandescent and arc lamps.

Chaps. iv. and v. are again of a descriptive nature, the former dealing with flashing signs, battery charging, motors, and starters, and the latter with electric bells, telephones, &c., and the circuits connected with them.

The book concludes with a short chapter on testing, particularly insulation tests of cables and installations. We observe that it has been brought thoroughly up to date by the addition of particulars of the latest practice and devices, and its value should be considerably enhanced by these new data.

Electric Wiring Diagrams. By W. Perren Maycock, M.I.E.E. (Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C.) 2*s.* 6*d.* net.

THIS is a collection of most of the diagrams given in the above work, with abbreviated explanations. It is intended as a reference work for those to whom a diagram is almost self-explanatory.

Dictionary of Electrical Engineering. Edited by H. M. Hobart. (The Gresham Publishing Co., 34-35, Southampton Street, Strand, London, W.C.)

THIS work, which is published in two volumes and runs into 630 pages, resembles in the scope of some of the articles an encyclopædia. On the other hand, it is largely concerned with the special duty of a dictionary—the precise definition of terms. It is interesting to note that in addition to purely electrical nomenclature, such as that defined by the International Electrotechnical Commission, there is included a comprehensive series of terms used in illumination and illuminating engineering.

The ground covered is considerable, ranging from the central station to insulating varnish, and from Ohm's law to the theory of single phase motors; the usefulness of the volume is increased by copious references to other sources of information, and a feature of the dictionary is the elaborate cross-indexing, which enables any question to be studied in a variety of aspects.

The information is thoroughly up to date, and the different sections have been dealt with by eminent men, each of them specialists in the particular branch treated.

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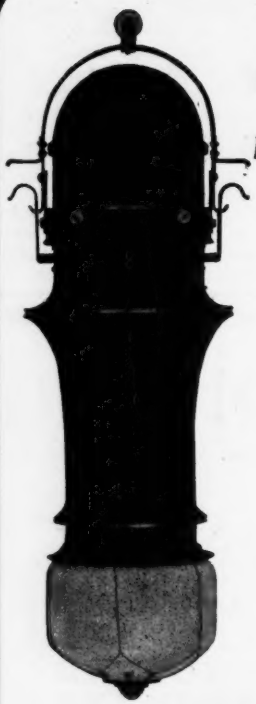

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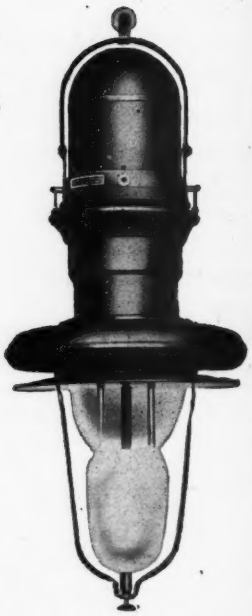

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The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON GASTER

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EDITORIAL.

The Reflective Power of Walls and Ceilings.

READERS will find on pages 280-9 the two papers read by Mr. Haydn T. Harrison and Mr. P. J. Waldram at the last meeting of the Illuminating Engineering Society dealing with "The Ratio of Light to Illumination" and "Some Notes on the Effect of Wallpapers on Illumination." The last point is one which has quite frequently attracted the attention of lighting engineers, and it will be recalled that in a recent number of this journal we published an article by Professor H. Bohle, of Cape Town, giving the results of a series of tests on the subject.*

The title of Mr. Harrison's paper expresses briefly what seems to be the kernel of the matter. In lighting an interior the engineer is concerned with the problem of converting a given flux of light, yielded by certain lamps installed, into *illumination*. The light must be so distributed as to enable people to read and write in comfort at the tables, to see the pictures and ornaments on the walls, &c. Success in this respect depends mainly on judging how much illumination ought to be allocated to each purpose, and in recognizing how the reflecting power of walls and ceilings can be turned to the best advantage.

It is here that the skilled illuminating engineer may expect to improve on the results obtained by crude rule of thumb methods. If the method of illumination adopted allows too much light to escape upwards and undergo absorption by dark coloured wall-papers a correspondingly great expenditure of energy will be required. If, on the other hand, too little light is allowed to the walls, the consumption may be low, but the result may be unsatisfactory and depressing.

But if the units are properly placed, and equipped with the correct forms of

* *Illum. Eng.*, Lond., vol. iii., March, 1911.

shades and reflectors, and if, in addition, the influence of the scheme of decoration employed is carefully borne in mind, the contractor may be able to light the room quite satisfactorily and yet to use only a fraction of the energy which a rule of thumb method might entail.

As Mr. Harrison points out, it is somewhat hard to draw definite conclusions from much of the literature published on this subject. Terms are sometimes used in a misleading manner, such expressions as *candle-power*, *flux of light*, *illumination*, *surface-brightness*, *intrinsic brilliancy*, and *luminosity* being employed with distinctly different meanings by various observers. It is to be hoped that the Illuminating Engineering Society will be able to clear up these matters, but it is necessary to proceed cautiously, and, in making new suggestions, to bear in mind the work that has already been done in this direction. In this connexion we should like to draw attention to the contribution by Prof. Blondel in this number (p. 265), and also to a list of definitions recently put forward by the Illuminating Engineering Society in the United States.*

The discussion served to show that considerable progress has been made in applying methods of measurement to these problems. It was pointed out that we are now in a position to measure the surface-brightness and illumination of any wall-paper and to deduce therefrom the reflecting power. Figures were also put forward to demonstrate that these values can be predicted with some accuracy when the polar curves of light distribution of the units employed are available; from such curves we can also readily calculate how much of the total light produced is concentrated downwards, how much is allowed to escape sideways and upwards so as to illuminate the walls and ceilings, and how much is wasted in absorption in different cases.

With full knowledge on these points the scientific prediction of the exact conditions of illumination which will be secured in a given installation becomes a practical possibility. Our chief object must now be to encourage the practice, on the part of manufacturers, of furnishing precise information on these points with the units supplied. We also need to form somewhat more definite conclusions regarding the requirements of different interiors. Progress in this direction has been made, but the subject is very far from being exhausted. It may be hoped that the Illuminating Engineering Society will turn its attention to the matter again before very long and that the gaps in our knowledge will soon be filled by additional information in further interesting contributions.

A National Movement for the Preservation of Vision.

We notice, in the last number of *The Illuminating Engineer* of New York, an account of a movement originated in the United States with the object of drawing attention to the bearing of good illumination on eyesight.

A meeting of the American Association for the Conservation of Vision, which has this matter in hand, took place on March 25th of this year, Dr. E. Park Lewis being the first appointed President of the association. Many different experts and associations appear to be interested in the movement. The combined efforts of the illuminating engineer and the oculist are needed; but the results of their work are also of considerable interest to many industrial and insurance companies. We notice, for example, that among those who spoke in support of the movement were Dr. Louis Bell and Dr. E. P. Hyde (both past Presidents of the Illuminating Engineering Society in the United States), and that Dr. Hyde gave an account of the work on the connexion between physical and physiological aspects of illuminating

* *Illum. Eng.*, Lond., Feb., 1911, p. 74.

engineering now being carried out in the laboratories of the National Electric Lamp Association. Among others who joined in the discussion were Mr. Bolling, of the United States Steel Corporation, and Mr. Law of the Fidelity and Casualty Co., who alluded to the efforts now being made with the object of reducing the number of industrial accidents. The movement has also gained the support of a number of affiliated associations dealing with defects of vision and the prevention of blindness.

In these days we are accustomed to national movements having for their object the prevention and alleviation of disease, a notable instance being the campaign against tuberculosis in this country. Now the preservation of eyesight is also a subject of national importance; we therefore venture to suggest that there is need of some better means of organizing research on the effect of illumination on vision. Artificial illumination, on the scale to which we are now accustomed, is of quite recent growth. We have hardly yet had enough experience to say in what respects this extended use of artificial light may have unsatisfactory results; but we can point—and with some conviction—to certain obvious defects in methods of using the brighter illuminants which we believe to be prejudicial. There are two matters which have recently been the subject at the discussion of the Illuminating Engineering Society in this country, the avoidance of glare, and the provision of sufficiency of light for reading, writing, and various industrial processes, which would alone furnish ground for very careful study.

We have every reason to regard these two matters as most vital to the eyesight, but we still desire to set in motion machinery for collecting practical data on the subject. It would be beneficial, for example, if statistics could be accumulated regarding the bearing of the conditions of illumination on the eyesight of children in schools and operators in various kinds of workrooms and factories; it would also be of service if similar data could be obtained enabling us to trace the effect of good and bad illumination on the occurrence of accidents in industrial employment. One frequently finds that in impressing the importance of these matters on engineers and lighting experts one is preaching to the converted. Among them the justice of our contentions in favour of sufficiency of illumination and an absence of glare, for example, is very generally admitted. But the wider general public has still to be educated to appreciate these points, and until this is done illuminating engineers will continue to labour under considerable disadvantages.

Meantime there is a commercial aspect of the matter which must not be ignored. While the present obscurity regarding the physiological aspects of illumination is allowed to prevail, it is difficult to refute the purely partisan and misleading statements occasionally circulated regarding one or another illuminant. While no one knows, it is open to an individual to express a view of this kind, however misleading, with impunity. But if once the question of the effect of different illuminants on sight were thoroughly threshed out, this tendency to misleading statements would decline, for their complete refutation would then present no difficulty.

A Combined Gas and Electric Lighting Tender in Holborn.

Readers have doubtless been interested in the discussion that has been proceeding regarding the renewal of the contract for public lighting of Holborn, where tenders submitted by the gas and electric lighting companies have been under consideration for some time.

A very interesting development, which has received a considerable amount of notice in the gas and

electrical journals, has now taken place, namely, the presentation of a joint specification agreed upon by the Gas Light and Coke Company and the several electric supply companies interested; in this, it is stated, the main lines of the specification of the Surveyor of the Borough are followed, but it is suggested that a combined system of lighting should be adopted, some streets being illuminated by gas and others by electricity. It may be added that the suggested system is regarded as a distinct advance on present conditions, seeing that a considerably increased illumination is specified at a reduced cost.

This has been generally regarded as a most interesting and striking precedent, and we notice that the *Electrical Times*, from which we reproduce a note on this subject, hails it as the "first visible sign of the approaching millennium." To those who, like ourselves, have frequently pointed out the desirability of co-operation between the gas and electrical interests, the development is less astounding, but it is naturally gratifying to observe this new instance of concerted effort and mutual toleration. While hardly deserving to be regarded as a "sign of the millennium," the incident may surely be regarded as a sign of the times. We venture to think that it may be, at least in part, ascribed to the development of the illuminating engineering movement in this country and its influence in favour of a more reasonable attitude between competitors in artificial lighting.

Evidence of the possibility of such toleration is presented by the successful concerted action of gas and electrical departments, where both are owned by the local municipality. But the present case, in which two unconnected competitors have apparently met together in order to find ground of common agreement, seems to be something new, and we shall watch with interest the developments following this interesting precedent.

The Profession of Illuminating Engineering.

The Illuminating Engineering Society in the United States has now entered upon its sixth year of existence. During the past year the Society has again made remarkable progress. Not only has the standard of papers read been uniformly high, but the membership has now reached 1,478 — an increase of no less than 42 per cent over during the last year.

It is natural, therefore, that the scope of the Illuminating Engineering profession should now become more clearly defined, and the new President, Prof. A. E. Kenelly, took this subject for his Inaugural Address.

Prof. Kenelly lays stress on the multiplicity of subjects with which an acquaintance is necessary. He points out that the Illuminating Engineer is inevitably brought in contact with the qualitative, quantitative, social, and decorative sciences. He must understand the purely engineering aspects of efficient light distribution, must subject his engineering conclusions to his business sense, and must again reflect upon the artistic side of his work before forming a final decision. During the next few years he will probably be called upon to study this last aspect of lighting with some assiduity. He must appreciate the fact himself, and he must teach the general public, that good lighting is essentially unobtrusive and in harmony with its surroundings; artistic, but not necessarily ornate; and he must learn to weigh the desirability of securing the most perfect artistic results with the need of practising engineering economy.

But perhaps the most happy description is given by Prof. Kenelly, when he refers to the Illuminating Engineer as essentially a man with a "sympathetic understanding of other men's work." The Illuminating Engineer should appreciate to the full the need for co-operation and compromise, and he could hardly adopt a better motto.

LEON GASTER.

Review of Contents of this Issue.

THE article by MR. W. BASSETT JONES, JUN. (p. 261), on the **Lighting of the Allegheny County Soldiers' Memorial** is concluded in this number. Further particulars are given of the lighting of the great auditorium, and figures presented for the illumination obtained on the floor when all the lamps were in use and with different combinations of the various illuminants. In describing the scheme adopted for the illumination of the Banquet Hall, the author shows that the measured illumination agrees with that predicted by the original calculation, and indicates how the loss of reflected light due to accumulated dirt was estimated. Mention is made of a difficulty which occurred in lighting the entrance foyer so as to display satisfactorily the architectural features, and the manner in which this was remedied by the use of tinted lights.

On p. 265 PROF. A. BLONDEL contributes a **Note on Illuminating Engineering Nomenclature,** which is in the nature of a reply to some points recently raised in our correspondence columns. Prof. Blondel gives his reasons for disagreeing with the proposed introduction of a "secondary unit" of intrinsic brilliancy, and presents a list of various accessory photometric quantities, which he thinks it would be desirable to add to those already tabulated.

This is followed by the second part of an article by DR. W. W. COBLENTZ on the **Selective Emission of the Acetylene Flame** (p. 267). He has investigated the probability of an abnormal emission beyond $0{\cdot}7\mu$ in the spectrum in a number of different ways, and comes to the final conclusion that, so far as his experiments go, there is no selective emission in the spectrum of the acetylene flame.

PROF. S. A. RUMI (p. 273) contributes an article on the **"Carbone" Flame Arc Lamp,** in which he describes certain special features which were embodied in this lamp in order to overcome some of the early difficulties (*e.g.*, the screening of moving parts from the fumes given off by the carbons, and the prevention of deposits on the inside of the globe). The author gives the results of some tests he has carried out on this lamp, and describes his method of testing the efficient ventilation of the lamp by injecting smoke while it was burning.

An account follows of the **Artificial Lighting of the large Tennis Ground** recently opened at Dulwich, in which high-pressure gaslights, with special screens and reflectors, are used. The entire surface of the courts and the surroundings are painted a dead matt black, only the lines of the courts, the balls, and the cords at the top of the nets, being made as white as possible. A number of special features of interest in this striking installation are pointed out, and values of the illumination at various points are given. The article includes some interesting details with regard to surface brightness and contrast, and the effect which these have on the eye when following the flight of the ball. It is pointed out that the conditions of light contrast between ball and background in an indoor court can be controlled to a much greater extent than is possible out of doors, and it was therefore thought that experiments of the above kind might be of value to those concerned with the design of installations of this kind (p. 273).

The section devoted to the *Transactions* of the **Illuminating Engineering Society,** contains an account of the meeting of the Society on April 24th, when papers were read by MR. HAYDN T. HARRISON on **The Ratio of Light to Illumination,** and by MR. P. J. WALDRAM on **Some Notes of the**

Effect of Wall Papers upon the Illumination of Interiors. A brief report of the meeting is followed by these two papers *in extenso* (p. 280).

The former paper deals mainly with various terms, such as "intrinsic brilliancy" and "luminosity," which are employed in dealing with problems of this character, and a table is given, summarizing the effects of reflection from wallpapers of various colours. The paper by Mr. Waldram discusses the effect of such reflection on illuminating engineering calculations and the possibility of predicting its exact effect beforehand. Some experiments having for their object the analysis of the amount of direct light, and the light reflected *via* walls and ceiling, are also described, and an account is given of some special apparatus devised for the purpose. It is mentioned that the complete account of the discussion of these papers will be published in the next number.

The **Notes on the Illumination of Various London Schools and Colleges,** by MR. LEON GASTER and MR. J. S. Dow are concluded in this number. A table is given of the illumination found in some German schools, showing a relatively high illumination and a good uniformity. Visits to various public schools and colleges are described, and the various types of electric and gas fixtures met with are illustrated and discussed. The article concludes with some values of daylight illumination, and a note on the dimensions of windows in school-rooms, and special reference is made to the question of local lighting for the teacher's table and the blackboard.

Among other matters discussed in this number reference may be made to the **Combined Specification of Gas and Electric Lighting** which has been suggested by the gas and electricity supply companies concerned for the public lighting of the Borough of Holborn. The incident is interesting, as illustrating the tendency towards concerted action and tolera tion between competitors and representatives of different systems of lighting.

On p. 301 will also be found an article summarizing, in an exhaustive manner, the suggestions that have been put forward in the past regarding street-lighting contracts, and their bearing on the proposed **Standard Specification for Street Lighting.** Some contracts have been suggested based on "selling illumination," others depend mainly on the supply of gas or electrical energy, and others again involve *both* the specification of light and the measurement of consumption. The question is also raised whether it is better to determine the candle-power of the lamps or the actual illumination in the street; a further matter is the desirability of measuring illumination in a vertical, horizontal, or inclined plane; it has also been suggested that mean, minimum, and ratio of maximum to minimum illumination should be stated so as to guarantee both sufficiency of illumination and uniformity.

The recent Ophthalmological Exhibition held at the rooms of the Royal Medical Society is referred to, and the meeting of the Institute of Sanitary Engineers, at which a paper dealing with **Illuminating Engineering and Hygiene** was read by MR. L. GASTER, is briefly reported. This paper laid special stress on the need for the study of illumination by sanitary engineers, and the appreciation of such matters as the effect of light on health and cleanliness.

Among other recent papers reported is that by MR. J. S. Dow and V. H. MACKINNEY, entitled **Surface Brightness and its application to Photography.** It is suggested that by making actual measurements of the brightness of objects photographed, the desirable exposure can be judged with considerably greater accuracy.

There are also the usual **Short Notes on Illuminating Engineering.**

The number concludes with **Trade Notes** and the **Review of the Technical Press.**

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

The Lighting of the Allegheny County Soldiers' Memorial.

By Bassett Jones, Jun.

[Abstract of paper read before the Illuminating Engineering Society in the United States, December, 1910.]

(*Concluded from p. 202.*)

The lighting of the auditorium is controlled by switching devices in a closet off the stage, so that any feature of the lighting may be turned on or off at will. It is intended that either the light from the glass sashes or the light from the exposed lamps under the ceiling will be sufficient for ordinary purposes, while the entire lighting system will be used only on special occasions. But, as a matter of fact, the illumination has proved so popular as an exhibition in itself that it has been featured on every occasion, the audience usually remaining to view the various effects.

The cost of installing the auditorium lighting was remarkably low, as the cost of fixtures appropriate for lighting this immense room would have almost equalled the cost of the present illuminating equipment of the entire building.

The nitrogen-vapour tube lamps, mercury arcs, and flame arc lamps are used solely for effect, efficiency not being considered, since the particular effects desired could not be obtained in any other way. To use incandescent lamps with colour screens in place of nitrogen tubes and mercury arcs would require the use of very expensive screens of specially burned glass without any certainty that any one melt would have produced the correct tint. Furthermore, the exact character of light required cannot be attained by any such method. Of course no substitute can be found for the flame arc lamps that will give a scintillating flux.

Some difficulty was experienced with the pierced plaster grilles under the flame arc lamps because the contractor for the plaster work had made the castings too thin. After some experimenting, and as a temporary device, the grilles were covered above with thin cheese cloth, which prevents the construction of the ceiling from being seen. The cheese cloth is entirely disguised and gives a solid appearance to the grilles. These grilles will eventually be covered with circular sashes of deflex glass.

Frosted-tip tungsten lamps were first used in the rosettes under the ceiling, but the great intrinsic brilliancy and excessive whiteness of the light from these lamps when contrasted with the generally soft yellow tone of the rest of the illumination produced unfortunate results, and, with the exception of the centre lamp in each group, they were replaced with 8 c.-p. frosted-bulb carbon-filament lamps.

Thirty different effects can be obtained in the lighting of this ceiling, fourteen of which are really beautiful. The most interesting series of colour

changes is obtained by starting with the mercury arcs alone, and adding the remainder of the illuminants in the order following: 1. Nitrogen-vapour lamps; 2. flame arcs; 3. sashes; 4. exposed incandescents. The most remarkable effect is obtained by using only the nitrogen-vapour lamps and flame arc lamps. The ceiling then appears like a huge decorative grate above which great fires are burning. The maximum intensity on the floor then reaches 0·7 foot-candle. Adding the mercury-vapour lamps to this combination does not change the illumination on the floor, due to the form of the reflectors used with these lamps, but the effect produced is most weird, and profoundly alters the colour of the walls to a grey blue. The light from the nitrogen-vapour lamps so completely detaches the panels from the ceiling that they appear actually to float in their frames, and the slight flickering of the light that sometimes occurs seems to set them moving.

There are two general colour effects obtainable in the illumination of this room, each of which may be varied through several tones; these are rose-gold and silver-blue.

The maximum intensities of illumination on the floor for different combinations, readings being taken at the centre of the auditorium, were as follows:—

	Foot-candles.
1. All lamps in use ..	3·82
2. Exposed incandescent lamps and sashes ..	3·10
3. Sashes only	1·46
4. Exposed incandescent lamps only	1·74
5. Nitrogen tubes only ..	0·40
6. Flaming arc lamps only	0·30

The above readings were taken directly after the work was completed, and with a large amount of accumulated dust and dirt on the sashes. The results are therefore the worst that can be obtained, since once the sashes are cleaned the box reflectors will prevent any serious lowering of the intensity due to a similar cause. The loss due to dirt amounted to at least 20 per cent of the lamp flux.

The power consumption per square foot of floor area is, for the sashes, 4·03 watts; for the exposed incandescent lamps, all tungsten, 1·20 watts, and for part 8-c.-p. carbon lamps, 1·14 watts. The total power "let loose" above this ceiling, including the exposed incandescent lamps, amounts to 117·20 virtual kilowatts with all lamps in use.

Lighting of the Banquet Hall.

The lighting of the banquet hall was a comparatively simple matter compared to the lighting of the auditorium—no special difficulties were anticipated, and none were met.

As above explained, there are 49 glass sashes in the banquet-hall ceiling, each sash forming the top of a ceiling coffer. (See Fig. 1.) The area of each sash is 25 sq. ft., from which 10 per cent should be deducted for sash bars and mullions, leaving 22·5 sq. ft. net glass area per sash—a total glass area of 1,100 sq. ft. Above each sash is a box reflector similar to those used over the sashes in the auditorium ceiling. Each reflector contained eight 40-watt clear-bulb 112-volt tungsten lamps.

On a basis of 40 per cent efficiency with clean sashes, the loss by accumulated dirt is found as follows: Measured—I = 2·86 at centre of hall. Deducting 0·46 for illumination due to gallery lamps, and allowing a reflection coefficient of 20 per cent, gives I=2·00. Total generated flux per sash=8 lamps × 300 lumens = 2,400 lumens. Net lumens per sq. ft. glass on a basis of 40 per cent efficiency and 10 per cent loss by mullions, &c. (giving a net efficiency of 36 per cent)=34 lumens. Apparent specific intensity per sq. ft. glass=10·8. Total glass area=1,100 sq. ft. Total area ceiling=5,476 sq. ft. Equivalent specific intensity per sq. ft. ceiling = 2·2. Calculated I at centre of hall = 5·60. The apparent value of i per sq. ft. of ceiling that would produce a value of I = 2·00 is 1·00. The apparent equivalent flux per sq. ft. of ceiling is therefore 3·14 lumens. The total apparent flux is then 3·14 lumens × 5,476 sq. ft. = 17,200 lumens. The total generated flux is 117,600 lumens. The actual efficiency is therefore 20

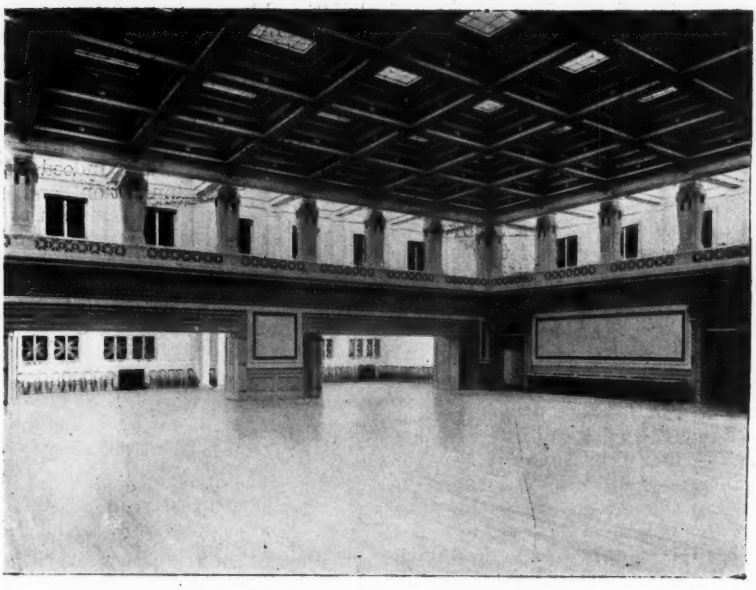

FIG. 4.—View of Banquet Hall taken at Night.

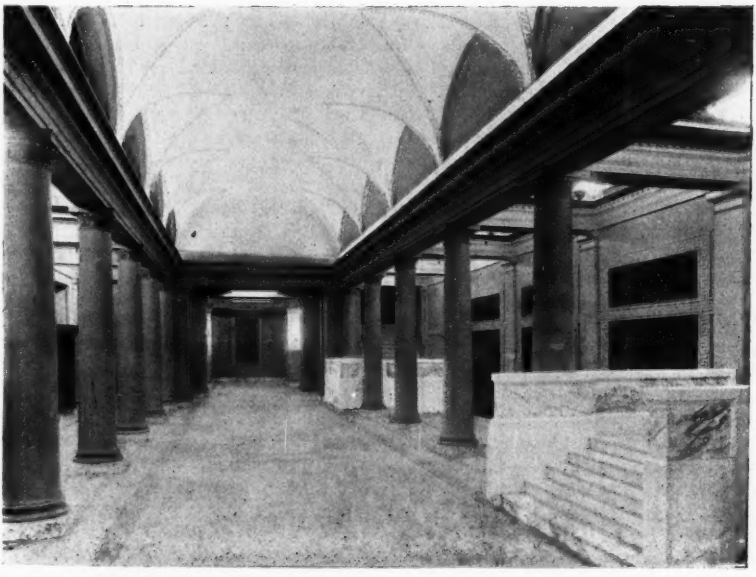

FIG. 5.—Artificial Illumination of Entrance Foyer.

per cent, giving an approximate loss by dirt of 20 per cent of the generated flux.

Lighting of the Entrance Foyer.

It was originally proposed that the lighting of the vaulted foyer ceiling should be accomplished by completely concealed light sources. (See Fig. 2.) The design provided a projecting cornice on each side and end, and a cove was built in the upper side of this cornice of sufficient size to receive a trough reflector using silvered Belgian rippled glass as a reflecting medium.

The effect of the very careful work with this reflector is a good example of what was meant above when speaking of the relation of light to architecture. The illuminating result was exactly that intended. The brightest part of the vault was the part farthest from the reflector, the darkest part that just over the reflector. A moulding just above the reflector, parallel to the cornice, consisting of an ogee below painted blue and a fillet above painted red was less brightly illuminated on the round of the ogee than was the perpendicular plaster surface one foot above. Furthermore, the uninitiated could not tell where the light came from. The ceiling was luminous, and that was all. But the æsthetic result was that the vault appeared flat, the cornice receded and became apparently a decorated spring band in the plane of the spandrils of the longitudinal window arches. The architecture was ruined.

The work was begun over again, and, as luck would have it, when the reflector was turned over bodily on its axis through a few degrees, the ceiling became evenly illuminated from the back of the cove to the apex of the vault; a little further, and the brightest part was just over the cove. The cornice at once acquired its full value, and the vault became hollow. But still the lighting was too smooth—the foyer had lost some of its depth. To remedy this the reflector glazing was replaced with coloured glass—flashed ruby being used under the spring of each of the longitudinal arches, and burnt amber between. The result of this treatment was literally to paint the vault with light. It is an extraordinary fact that the use of coloured light to tint surfaces in architectural compositions has never been developed. Here, indeed, is a new theme in illumination, and one that has unlimited possibilities if studied intelligently. Furthermore the use of grilles or decorative silhouettes interposed between the light source and the surfaces to be lighted so as to cast shadow arrangements can often be employed with telling effect. In this foyer there is such a result in its simplest form where the fan-shape darker ruby areas on the arch spandrils melt into the rosy amber areas of the main vault.

Acknowledgements.

The author desires to acknowledge his indebtedness, first, of course, to Messrs. Palmer and Hornbostel, the architects, for "leave to print," second, to Mr. Henry Hornbostel, to whom he largely owes whatever ideas he may have on the subject of illumination, for careful proof reading and for criticisms of this paper; third, to the Hon. J. G. Chalfant, county engineer, whose appreciativeness and goodwill did much to expedite matters; fourth, to the Iron City Engineering Co., of Pittsburgh, the contractors for the installation, whose efforts, interest, and care have contributed largely to its success. To Mr. W. D'A. Ryan the writer owes thanks for checking results and for excellent criticism of the engineering features of the designs, and to Mr. D. L. Wright, representative at the building for Allegheny County, for untiring efforts in arousing public interest and for much friendly assistance.

The test readings were made by Messrs. H. V. Allen and C. J. Mundo, using the Ryan luximeter. The remarkable photographs of the interiors taken by artificial light are the work of Mr. B. H. Norris.

A Note on Illuminating Engineering Nomenclature.

By Prof. A. Blondel (Paris).

The remarks on the above subject of a correspondent in a recent number of *The Illuminating Engineer* (March, 1911, p. 176) lead me to make a few comments on illuminating engineering nomenclature.

(1) I beg permission to protest against the proposed introduction of a so-called "secondary unit" of intrinsic brilliancy, and for several reasons :—

(a) The unit is quite useless since the Sub-Committee on Units has already defined "intrinsic radiation" (as I had previously done at the International Electrical Congress at Geneva in 1896) as the quotient of the luminous flux emitted by a surface by the radiating area of the said surface. It is easy to see that when this is applied to a diffusing surface of albedo unity the intrinsic radiation is exactly equivalent to the illumination (éclairement) expressed in lumens per square centimetre.

For example an ideally white surface absorbing absolutely no light, placed at a distance of 1 metre from, and facing a source of light yielding one candle receives 1 lumen per square metre, or one ten-thousandth of a lumen per square centimetre ; this last figure therefore is also a measure of its intrinsic radiation. If one presumes that the diffusion follows the law of Lambert the intrinsic brilliancy presented to the eye, at an angle β to the normal, will be :—

$$\frac{1}{10{,}000} \times \frac{\cos \beta}{\pi} \text{ candles per sq. cm.}$$

If the albedo is less than unity, if it is equal to $1 - a$ let us say, a being the coefficient of absorbtion, the intrinsic brilliancy becomes simply :—

$$\frac{1 - a}{10{,}000} \cdot \frac{\cos \beta}{\pi} \text{ candles per sq. cm.}$$

If, on the other hand, the surface does not follow the Lambert law but some complicated function of the angle of emission of the form $f(\beta)$, the intrinsic brilliancy finally becomes :

$$\frac{(1 - a) \cdot f(\beta)}{10{,}000 \cdot \pi} \text{ candles per sq. cm.}$$

All this is quite clear and serves both to show the utility of the physical quantity "intrinsic radiation," and at the same time to demonstrate the futility of introducing a secondary unit.

(b) The secondary unit proposed (or "surface brightness"), also presents the fundamental defect of being based purely and simply on two suppositions, namely that the albedo is unity and that the surface follows the Lambert Law. In the previous propositions I have not made any assumption of this kind, and the last formula is completely general and applies whatever the nature of the surface.

(c) Moreover, in my opinion, there is no special scientific desirability to distinguish between light emitted by a self-luminous surface and light radiated by a diffusing illuminated surface ; on the contrary it is preferable to treat both alike as sources of light.

(d) The word "surface brightness" has no special meaning attached to it and does not satisfy any new need. The "intrinsic radiation," on the other hand, *does* correspond with an actual practical want, namely, the desirability of expressing the total flux of light emitted by a luminous surface which does not comply with the Law of Lambert. In general one measures intrinsic brilliancy in a direction perpendicular to the surface, but this does not suffice to define completely the emissive power of a source ; the intrinsic radiation, on the other hand, does enable us to express the total luminous efficiency.

I hope that these remarks will serve to show that the propositions of the Sub-committee are the result of well-

founded deliberations and, without pretending that they are above criticism, I yet do not consider that they require modifications on the lines suggested by "An Engineering Correspondent."

(2) There are, however, a certain number of accessory photometric quantities which it would be desirable to add to the existing list with a view to facilitating the comparison between various sources of light. Some such quantities are summarized in the accompanying table.

These various symbols need not be included in an official list at present, and may be taken into consideration at a later stage. They should, however, commend themselves to those interested in the technicalities of the subject. It may also be suggested that their tentative use would help to promote a much needed international uniformity in publications on illuminating engineering, and would be of value in supplying precise definitions of the physical quantities on which this subject is based.

PHYSICAL AND PRACTICAL CHARACTERISTICS OF SOURCES OF LIGHT.

$J_{\bar{\circ}}$	=	MEAN SPHERICAL LUMINOUS INTENSITY, expressed in international candles.*
J_r	=	MEAN HORIZONTAL LUMINOUS INTENSITY, expressed in international candles.
$e_{max.}$	=	INTRINSIC BRILLIANCY (Éclat intrinsèque) measured in the direction of maximum intensity and expressed in international candles per sq. cm.
P	=	POWER CONSUMED by a source,† expressed in watts (a portion of which is dissipated by radiation, and the remainder by conduction and convection).
$\frac{P}{J_{\bar{\circ}}}$	=	POWER CONSUMED PER CANDLE (or specific consumption of power), expressed in watts per international spherical candle.
$R = \int_0^\infty R_\lambda \, d\lambda$		TOTAL POWER RADIATED by a source, expressed in watts. (R is the power emitted by a source in the form of radiation of wave-length comprised between o and ∞
$R_e = \int_{\lambda=0{\cdot}4\mu}^{\lambda=0{\cdot}8\mu} R_\lambda \, d\lambda$		AVAILABLE USEFUL POWER for lighting purposes, expressed in watts (radiation comprised between the limits of wave-length $0{\cdot}4\mu$ and $0{\cdot}8\mu$).
$\frac{R_e}{R}$	=	RATIO BETWEEN THE USEFUL POWER AVAILABLE FOR LIGHTING PURPOSES, and the TOTAL POWER RADIATED (or radiant efficiency).
$\frac{R_e}{P}$	=	RATIO of the USEFUL POWER AVAILABLE for lighting Purposes and the TOTAL POWER CONSUMED by a source.
$\frac{R_e}{J_{\bar{\circ}}}$	=	MECHANICAL EQUIVALENT OF LIGHT, expressed in watts per int. candle.
Q	=	TOTAL HEAT DISSIPATED PER HOUR, expressed in gramme-calories.
$\frac{Q}{J_{\bar{\circ}}}$	=	TOTAL HEAT DISSIPATED PER HOUR, PER CANDLE, expressed in gramme-calories per candle.

(*) The symbol is furnished with a horizontal projecting bar to avoid all confusion; either with a zero or with an e.

(†) This power or energy consumed per second by the source of light can be calculated, for flame sources, by multiplying together the quantity of combustible burned per second by the calorific heat and the energy equivalent of the calorie.

A Note on the Selective Emission of the Acetylene Flame.

By W. W. Coblentz.

(*Continued from p.* 666, *Vol. III.*)

In the prismatic curves, Fig. 1, the three dots at each point of observation, for example at ·7μ, indicate the maximum, the mean (of 10 to 15 observations) and the minimum deflections representing three series of observations made in rapid succession back and forth throughout the spectrum.

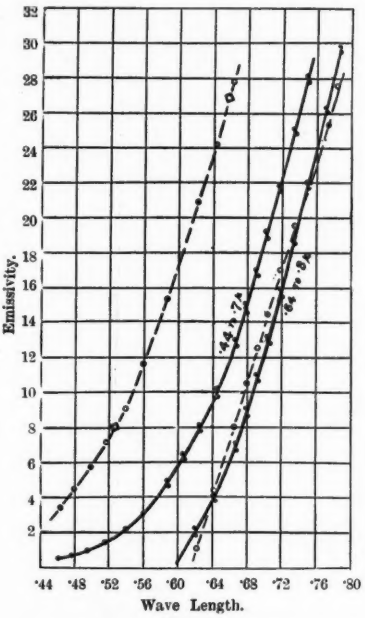

FIG. 1.

SPECTRAL ENERGY DISTRIBUTION OF ACETYLENE.

——— Prismatic Spectrum; Glass •••

– – – – Normal Spectrum { Quartz □ □ □ / Glass ○ ○ ○

The whole time consumed was less than 2 hours, with the barometer reading 755 mm. and a relative humidity of about 69 to 70 per cent. No irregularity is observable in the energy curves, greater than that due to fluctuations in the flame, and it can safely be said that from these curves no selective emission band with a maximum rising 1 per cent. above the general trend of the spectral energy curve, is present at ·7 to ·72μ. The spectrophotometric data would indicate a protuberance at ·70μ rising several centimetres above the general trend of the spectral energy curve. Furthermore, the spectral energy curves of carbon filament lamps obtained with this apparatus show no selective emission in this region. It is, therefore, an interesting question why the spectrophotometric intercomparisons of these two sources should indicate an abnormal emission beyond 0·7 μ. The very marked difference of their emissivities in the infra-red should produce a maximum in their ratios of intensities (see Fig. 2, *b* and *c*), but this maximum could hardly come so close to the visible spectrum. The exact location of this maximum will be indicated in the complete paper.

In Fig. 2, curve *c* gives the ratios of emissivities of acetylene (from Fig. 1) divided by the emissivities of a graphitized carbon ("Gem lamp") filament which was operated on 2·5 w.p.c. In this case the *flat side* of the flame was radiating into the spectrometer slit. In the meantime the acetylene generator was recharged and a new series of spectral energy curves were obtained which are given in Fig. 2 curve *a*. In Fig. 2, curve *b* gives the acetylene flame (radiating *edgewise* into the spectrometer slit) divided by the emissivities of the graphitized carbon. Curve *b* is slightly more bowed upward than curve *c*. Whether this is due to the quality of the gas, or due to the thicker radiating layer (which seems the more probable) would require a very extensive investigation. Curve *d* gives the ratios of the emissivities of acetylene divided by the emissivities of a treated carbon lamp

on 4 w.p.c. The slight depression at ·7μ vaguely suggests the conditions observed with the spectrophotometer, with the lamp at about the same temperature. Both curves *a* and *b* show a maximum in the region of ·54μ to ·56μ, indicating an abnormally high emissivity in acetylene in this region of the spectrum. That this maximum is due to the selective emission (of the type which obtains in metals) of acetylene follows from the fact that carbon filaments, examined with an optical pyrometer, show but little selective emission, while similar measurements

shape of the energy curve is shown in Fig. 2 (prismatic), curve *a*, which gives the radiation from the flat side (× × × and ....) and the edge (O O O O) of the flame. In this experiment the acetylene flame, radiating edgewise into the spectrometer slit, illuminated only about 1·5 cm. width of the prism face, which was therefore entirely covered except 1·5 cm. of the central part of the face. In this manner, the flat side of the flame illuminated the same width as the flame turned edgewise. The expectation was to find a marked increase in the emissivity in the red,

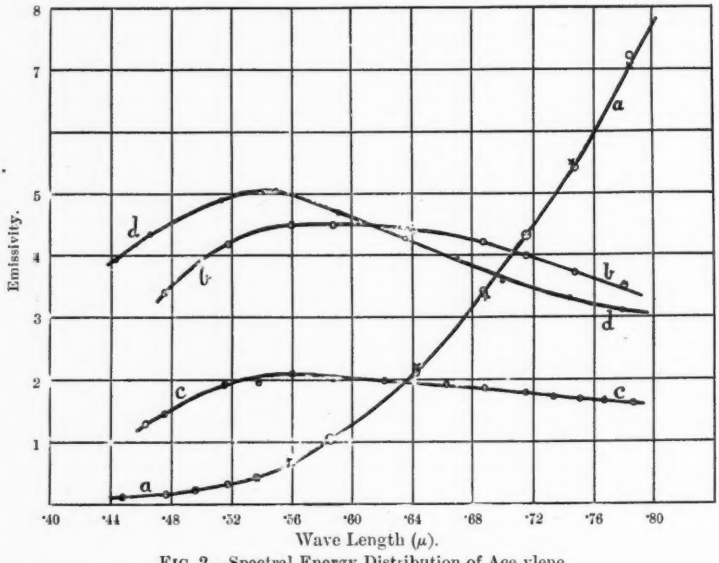

FIG. 2.—Spectral Energy Distribution of Acetylene.
Curve *a* { Flat side ××× and ...
Edgewise O O O O

(quoted on a previous page) show a high emissivity in the blue of the acetylene flame. The very important point to be noticed is that there is no maximum at ·7μ, such as was observed with the spectrophotometer. These radiometric ratios are exactly analogous to the spectrophotometric data, and since the original observations are accurate to at least 1 per cent. (which accuracy can not be claimed for the spectrophotometer at ·7μ) it is evident that the spectrophotometric data are erroneous. That the thickness of the radiating layer has but slight if any effect on the

when the flame was radiating edgewise into the spectroradiometer. The deflections were 11 times as large as those from the flat side of the flame, but when reduced to the same scale and plotted, as shown in curve *a*, Fig. 2, they coincide throughout the whole range. In this experiment the radiation from the flat flame (× × × × × ×) was first observed, then the flame was accurately adjusted edgewise (O O O O), and finally the observations were repeated on the flat flame (. . . . . .). The flame radiating edgewise was more sensitive to air drafts than when observed flat-

wise, and in all, less observations were made than for the curves in Fig. 1. Nevertheless there is an exact coincidence of the three series, showing the same relative emissivity when viewed flatwise as when viewed edgewise. This is probably to be expected in view of the fact that the variation in the absorptivity of the flame is not very marked in this spectral region, as observed by Ladenburg.

All the energy curves obtained with the cylindrical flame and with the flat flame (the latter radiating flatwise and edgewise into the spectrometer slit, and both flames operated under different pressures) are *straight lines* from ·56 μ to beyond ·78 μ. All other spectral energy curves, thus far observed, are very much curved in this region of the spectrum, due to the very rapid increase in emissivity with wave length beyond ·7μ. The acetylene curves show no selectivity at ·7μ, in the sense of a narrow band or protuberance rising sharply above the general trend of the spectral energy curve, and merging into the latter at nearby regions, for example, at ·67μ and ·73 μ. The straightness of the acetylene curve is hardly to be considered due to filling up, by selective emission, of the curved part of the spectral energy curve of carbon filaments, at ·7μ, but, as emphasized in a previous paper, is more probably due to the increased transparency of the incandescent carbon particles in the infra-red. In the infra-red, the spectral energy curve of acetylene is very deficient in radiation, as compared with the gas flame and especially the carbon filament. It seems evident that in comparing carbon filament against acetylene, the ratios of emissivities will be a curved line of which the position of the maximum will depend upon the temperature of the carbon filament as shown in Fig. 2.

In Fig. 2 the ratio of emissivities of acetylene to carbon indicate a maximum of emission in the region of ·56μ to ·60μ depending upon the temperature of the carbon filament. This maximum indicates a *decrease* in opacity in the ultra-violet instead of an *increase* in opacity with decrease in wave-length in the visible and ultra-violet, as heretofore observed on *cold carbon particles*. To prove that this conclusion is correct, the absorption of the acetylene flame was found for the region from the violet, through the visible spectrum, and into the infra-red. It was essentially a continuation of Ladenburg's work, which extended to about 0·7μ in the visible. His observations show a rapid increase in absorption in the visible spectrum which at first thought would lead one to infer that this is similar to the absorption of *cold* carbon particles. But the phenomenon is more complicated, for instead of a continued increase in absorption as we penetrate the ultra-violet, there is a well defined maximum at ·60μ to ·62μ as shown in Fig. 3. Now, heretofore, it has generally been supposed that flame* spectra exhibited but two types of emission bands: (1) sharp emission bands of gases due to the radiation of the heated products of combustion (for example, the emission band of CO_2 at 4·4μ); and (2) the radiation from the residual incandescent carbon particles which form an extensive band in the near infra-red with a maximum at 1·2 to 1·5 μ. But no really convincing data has been at hand, heretofore, which indicated a *true emission* band in the visible spectrum. All data, herewith presented, indicate such an emission band in acetylene. The next question is the probable cause of such a band. The theoretical combustion temperature of acetylene is of the order of 4,000 to 5,000° C. at the moment of disruption of the acetylene molecule. This high temperature can not exist due to the heat lost in warming the air, and to losses by radiation, so that the mean thermal temperature is about 1,800°. Similar emission bands, in other substances, have been ascribed to thermo-luminescence, and it is not unthinkable that the band at ·60μ is due to the emission of the acetylene molecule.

In conclusion it may be added that all experimental data, except several spectrophotometric comparisons, indicate the *absence* of a band of selective

* *The Illuminating Engineer*, London, vol. iii. p. 261, 1910.

emission at ·7μ in incandescent carbon. Certain physiological questions require further consideration before the spectrophotometric comparisons can be given much weight.

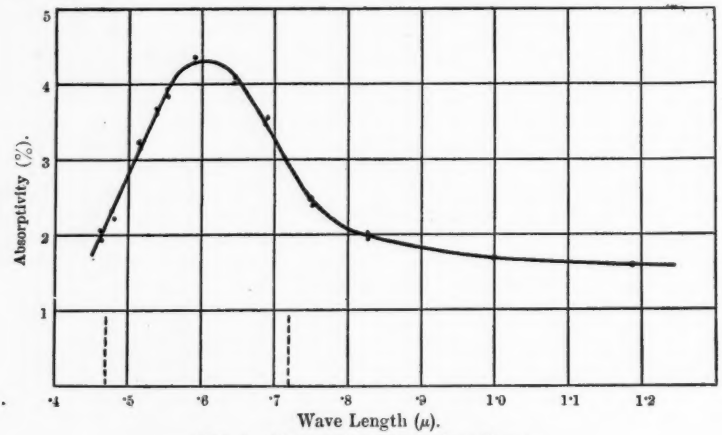

FIG. 3.—Absorptivity of Acetylene Flame.
(Dotted lines indicate limits of visible spectrum).

The data at hand show that amorphous carbon, lamp black, when cold, absorbs most in the violet and becomes more transparent in the longer wavelengths. This should produce an abnormal emission in the violet in the unsaturated radiation, from a thin layer of incandescent carbon particles, such as obtains in acetylene. The optical pyrometer shows such a selective emission, which is analogous to the type of selective emission in the visible spectrum of incandescent metals.

The Effect of a Line Choking Coil on the Candle-Power of Flame Arc-Lamps.

AN interesting point is raised in a pamphlet received from the Union Electric Co. relating to "Excello" flame arc-lamps. It is pointed out that for arc-lamps on alternating current circuits the use of a line choking-coil in place of a non-inductive line resistance, besides saving power, as is well known, actually increases the light value of the lamp. Oscillograph records of pressure and current under both conditions throw some light on the question. It is pointed out that the current lags at the commencement of each alternation, producing a distortion which is characteristic of flame arc-lamps. When, however, a line choking-coil is in circuit the pressure leads the current. Consequently at the moment when the current is zero, the pressure has almost attained the requisite value for creating the current, and so the current increases far more rapidly, without the flattening of the curve at the beginning of the cycle which occurs when a non-inductive resistance is used.

The illumination period, as compared with the dark period, is now longer during each cycle, and this, it is suggested, accounts for the rise in candle-power. In an actual example, when working from a machine having a sine wave E.M.F., the economy resulting from the combined effects of decrease in power taken and increase of c.-p. amounted to 36 per cent.

The "Carbone" (A.E.G.) Flame Arc-Lamp.

By Professor S. A. Rumi.

Every one is aware of the constant competition between gas and electrical illuminants and the constant improvements which such a condition of things tends to bring about. The great progress made in connexion with flame carbons is also fully recognized. Yet the incidental difficulties in connexion with such lamps, on which their practical success is largely dependent, and the manner in which these have been overcome, is at least equally interesting.

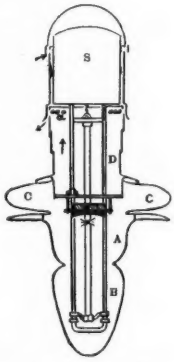

Fig. 1.—Diagram of Carbone Flame Arc Lamp.

One point, which was early recognized as important, was the necessity of screening moving parts from the fumes given off by chemical carbons; an allied difficulty experienced in many lamps was the deposition of such fumes on the inside of the globe. Many special systems of ventilation have been devised with a view to removing this drawback, but all have not proved equally successful.

An ingenious method of solving the difficulty was introduced some time ago by Mr. T. L. Carbone in Italy, who also devised a mechanism based on the action of a small alternating current motor. This method was eventually adopted by the Allgemeine Elektricitäts Gesellschaft in Berlin.

The arc is enclosed in a globe of peculiar shape consisting of two distinct parts. The upper part (A in Fig. 1) is opalescent; it completely surrounds the arc but allows a certain amount of light to pass through. The lower portion, B, is pear-shaped and

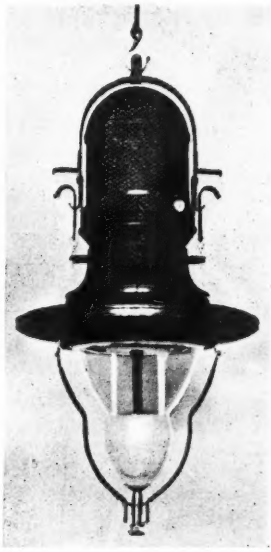

Fig. 2.
External View of Carbone Flame Arc Lamp.

composed of milky glass, and it is united with the upper globe by a cylindrical intermediate region. The globe is kept pressed tightly against the metal plate surmounting the carbon-holder.

The metallic part of the lamp consists essentially of:—

(1) A cooling space C, terminating in a plate and cup composed of refractory material, T, in which the arc is struck and maintained.

(2) A cylindrical portion D, above the plate T, and

(3) An enclosure S containing the regulating mechanism.

The advantage of this arrangement is that the heavier and denser portions of the products of combustion fall into the lower globe (well below the light-producing region); the temperature at this point was found to be about 50 deg. C.; it is much cooler than the upper portion of the globe A, which is relatively near to the arc.

The lighter products, on the other hand, pass into the space C and condense; the surfaces in this region are again relatively cool on account of the large radiating area presented. A small portion of the gaseous products diffuse slowly into the chamber D and emerge through the holes at the point *a*. I myself have proved this to be the case by injecting smoke into the lamp while it is burning. The essential point is that fumes cannot find their way into the chamber containing the regulating mechanism. As regards the nature of the solid products, analysis has shown that these consist mainly of calcium, sodium, and silicon and iron compounds; the nitrogen compounds find their way mainly to the lower part of the lamp.

The lamp yields a very efficient light and is admirable for illuminating large outdoor areas. The gaseous products of combustion, however, which emerge from the lamp into the atmosphere contain a considerable proportion of carbon monoxide, and the lamp is therefore best not used in confined interiors. The lamps taking 8, 10, and 12 amperes yield 800, 1,080, and 1,500 c.-p. respectively. (The absorption of the clear glass globe is estimated to be 10 per cent.) The specific consumption is stated to be 0·34 watts per candle. Lower results than this have been obtained, but it must be remembered that the carbons waste away comparatively slowly and only require renewal every 100 hours; this, of course, leads to a considerable saving in renewals and labour.

The London Ophthalmological Exhibition.

THE Ophthalmological Exhibition, announced in previous numbers of this journal, was held in the rooms of the Medical Society on March 10th and 11th, and an interesting collection of optical and electro-medical apparatus was assembled.

The exhibits included, in addition to a large variety of glasses, eye-testing apparatus, &c., Prof. Edridge-Green's colour-perception lantern. Other instruments for testing colour-blindness were also on view, and a recording ophthalmic camera for mapping an irregular curved surface, as exemplified by the conical cornea, was shown by Mr. J. H. Sutcliffe. There was also a demonstration of the Holophane system of illumination and the use of the Holophane Lumeter for illumination measurements.

A feature of the exhibition of interest to us was the series of short papers delivered on the first afternoon. Mr. Leon Gaster dealt with the subject of illumination and the eye, pointing out the importance of co-operation between the physiological and lighting experts. Mr. J. S. Dow gave a brief summary of progress in the measurement of illumination, showing how practical photometry had developed in recent years, and pointing out the value of such measurements in examining the conditions of lighting in schools, factories, &c. Mr. Mackinney spoke on the scientific distribution of light for different purposes, and exhibited a new form of reflector* designed to produce a uniform illumination over an extended area; one illustration of the value of such a reflector was furnished by the illumination of the type cards used for eye tests, which was illustrated by experiment.

Subsequently lectures were delivered by Mr. F. J. Selby on 'The Standardisation of Trial Cases, Lenses, &c., at the National Physical Laboratory,' and Mr. H. S. Ryland on 'Ophthalmic Lens Design and Lens Errors.'

* See *Illum. Eng.*, Lond., p. 145, March, 1911.

The Artificial Lighting of a Large Covered Tennis Ground.

(An account of the newly opened gaslighted tennis courts at Dulwich, S. London.)

DURING the last few years a notable advance has been made in methods of applying artificial lighting to athletics. In a recent number we referred to the lighting of a Racquets Court by the Holophane System of Illumination; and in the United States, very large areas, such as baseball grounds, have been lighted by artificial means, so as to enable play to take place in the evening.

The interest of this development to those concerned with outdoor games and athletics is obvious. Most people are restricted in the pursuit of their favourite game by inability to get away from business in the daytime. Many lawn tennis players, for example, are only able to practice during the light summer evenings, when their business engagements are over, and in winter, of course, have no opportunity at all of enjoying the game.

Recently, however, covered court play has come into existence, and championships played on such courts during the winter months have attracted quite a large amount of attention. A covered court, although suffering from certain inevitable drawbacks, has also some distinct advantages. For example, players are independent of climatic conditions and wind, and an even greater convenience is secured when the courts are provided with artificial light.

The problem of adequately illuminating a lawn tennis court is an exceedingly interesting one, and it therefore occurred to us that readers of this journal would appreciate an account of a striking installation of this kind which has just been completed in Dulwich (S. London). It should be mentioned that the King of Sweden has for some years had an artificially lighted tennis court in Stockholm. in this case, we understand, electric lamps, placed above a diffusing translucent screen, being employed. The essential idea is naturally to provide an even general illumination to screen the direct rays of the lamps from the eyes of players. But to return to the new court at Dulwich.

GENERAL NATURE OF THE BUILDING.

The building measures 158 feet by 134 feet and contains three courts. There is also accommodation, in the form of dressing rooms, for men and lady players, entrance hall, Hon. Secretary's office, &c., and a gallery runs the entire length of one side of the building so as to enable spectators to view the play in the three courts simultaneously. The roof is supported by steel framework between the courts, an intervening space of 15 feet being provided. The daylight illumination is secured by a large glazed skylight traversing the playing area; and the natural lighting so obtained is stated to be considered very successful by players. The remainder of the ceiling area is white in colour and thus assists the illumination; naturally, however, the large area given up to glass is an item that has to be carefully considered in planning the artificial lighting of the courts.

The surface of the courts and the surrounding walls are all painted a dead black so that the white balls, white lines of the courts, and the white border at the top of the net stand out prominently; this dark background is also found to be restful to the eyes. An ample space of 22 feet is provided to enable players to retreat behind the back lines and reach the ball when it falls near the back of the courts.

The speed with which the building and the lighting installation were completed testifies to the energy and organizing powers of the architect

responsible, Mr. H. M. Rootham, B.Sc., Assoc. M. Inst. C.E. It is stated that the first sod was cut on January 9th, and the first brick laid on January 15th of this year. Yet on Saturday, April 8th, the Court was thrown open to view and a series of exhibition games played under artificial lights by some of the best known British players. The whole period of erection and installation is thus within twelve and a half weeks.

The Artificial Lighting of the Courts.

We now come to the matter of chief interest to readers of this journal, namely, the artificial lighting of the building, undertaken by the South Metropolitan Gas Co. Here again one is struck by the rapidity with which the arrangements were completed once the method of lighting had been decided upon.

The gas is fed to the building by a special 3-inch pipe taken off the company's mains in the roadway. The lighting scheme falls into two portions. The courts themselves are illuminated by high pressure inverted Keith 1500 c.-p. lamps which are stated to consume 25 cub. ft. per hour each, and are hung at a height of 25 feet. There are eight lamps for each court arranged in the manner shown in Fig. 1. Assuming the ordinary price of gas in the district served by the S. Metropolitan Gas Co. (2*s.* 2*d.* per 1,000 cub. ft.), therefore, the cost of the gas consumption is reckoned at about 6*d.* per court per hour. The lighting of each court is separately controlled from the entrance hall, so that only those courts in actual use need be lighted up simultaneously. The gas is fed to these lamps at a pressure of 81 inches of water applied by means of a small compressor driven by a gas engine of about one H.P. and situated in an outhouse adjoining the main building.

Among the essential requirements in lighting a court of this kind are evenness and sufficiency of illumination and absence of glare. The former condition is secured mainly by the method of grouping the eight lamps over the court. In addition the lamps are provided with special Chappuis silvered glass conical reflectors around the mantle, and a frosted glass screen attached beneath it. This screen renders it impossible for the actual mantle to be perceived by the eyes of players, and the reflector is naturally of considerable assistance in concentrating the light downwards on the courts. The level of the lamps is also such that spectators in the gallery are unable to see the mantle, but only a portion of the ground glass diffusing plate. This

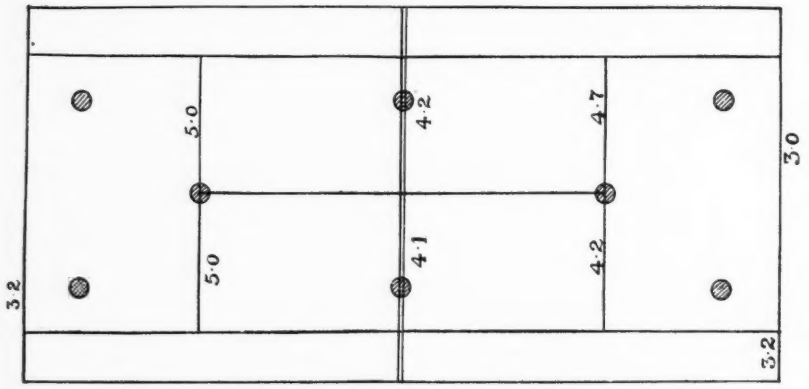

Fig. 1.—Showing arrangement of lamps above tennis court.

screen overlaps the reflector by about 4 inches and, while it transmits the majority of light downwards, is stated to allow a small amount (about 15 per cent) to strike the white ceiling. This serves a double purpose; it assists the direct lighting by a little inverted diffused illumination and so assists uniformity, and it reduces somewhat the contrast that would otherwise exist between the brightness of the frosted screen beneath the lamps and the ceiling surface above it.

The considerable height at which the lamps are hung, coupled with the diffusing action of the glass screens, is said to prove very convenient to the players, who have no difficulty in following the ball even when it is "lobbed" quite high up among the lamps (a height of as much as 35 feet being permitted in this building).

Lighting of Entrance Hall, Bathrooms, Gallery, &c.

The lighting of the dressing rooms is effected by low pressure Sugg double-burner lamps, and similar units are used to illuminate the top of the flight of stairs leading to the gallery; these latter lamps are completely screened on the side facing the courts so as not to interfere with the view of players; they are also sufficiently high up to be out of the normal range of vision of spectators. Two more single-burner "South London" lamps, similar to those used in many of the streets in the district of the South Metropolitan Gas Co., are placed on either side of the entrance to the courts.

One interesting feature of this section of the lighting is the use of the new "Metro" burner. This resembles the non-adjustable type designed for street-lighting and described by Mr. Carpenter at a meeting of the Illuminating Engineering Society on Nov. 8th, 1910. In addition to the advantage of requiring no regulation, the burner is stated to be very easily slipped apart for cleaning, and is provided with a bayonet joint for this purpose; the globe can also be detached by means of a joint of the same nature. These lamps are stated to consume 4 cub. feet per hour each.

Illumination Data.

Seeing that this installation is unique of its kind, and that it will doubtless serve as a model for other similar installations in the near future, it occurred to us that some particulars of the illumination provided would be of interest. Permission was kindly granted for some measurements to be made with the Holophane Lumeter instrument with a view to ascertaining the order of illumination provided and the uniformity of distribution.

Before giving these figures it should perhaps be made clear that, under the conditions prevailing, no direct calculation of the illumination from the nominal candle-power of the lamps used, and their height above the floor, was attempted. It would, of course, be misleading to attempt this, seeing that the 1,500 c.-p. specified does not take account of the influence of the special reflector provided, nor of the effect of the ground glass screen beneath each lamp. The values given, therefore, are those obtained by actual measurement and not by calculation. They were measured in a horizontal plane at the height of the net.

The approximate nature of the distribution of light over the central court will be understood from Fig. 1. Over the greater part of the court the illumination is between 4 and 5 foot-candles; behind the backline it is slightly over three. One would be inclined to suppose that this somewhat higher order of illumination over the central part of the court and near the net was desirable, for it is really this region on which the player's attention has to be mainly fixed. The conditions appear to have given every satisfaction to players, and it would therefore appear that about 4 foot-candles might be assumed as a tentative value for a court of this kind. Considering the fact that very little assistance can be derived from the very dark surroundings in this case, and that one has therefore to rely exclusively on direct illumination and correct grouping of the lamps, the degree of uniformity arrived at would

probably be considered quite satisfactory.

Surface Brightness Measurements and Contrast.

Now it is clear that in playing tennis there is one essential factor on which success in viewing the ball as it moves to and fro largely depends. This is the degree of contrast between the surface brightness of the light ball and the dark floor and walls. In outdoor courts the ball is usually seen against a grass background, but in an indoor court the background may be made very much darker than grass, and it would therefore seem conceivable that under these conditions it might be even easier to follow the flight of the ball than outside. In any case, presumably, one's aim should be to make the contrast between the ball and surroundings as intense as possible. This might perhaps be effected by dead black balls and dead white walls. This plan would materially assist the illumination, but is open to the possible objection that the walls would soon become dirty and a loss of contrast would ensue. In the present case, as we have seen, the method adopted was to make everything dead black except the balls, the lines of the court, and the top of the net, which are dead white.

It was suggested that some figures regarding the surface brightness of these objects might be of interest. Mr. Rootham appears to have been exceptionably successful in obtaining a dead black matt surface which does not rub off. When the white screen of the Holophane Lumeter instrument was hung up on the wall near the centre of the room, the surface brightness of the screen was about 2·0 foot-candles, that of the black walls only 0·06. The black wall, therefore, reflected only about 3 per cent of the light reflected by the ground white celluloid screen—a good result which it would probably be difficult to improve upon.

Naturally, however, in a large area of this kind one cannot avoid a certain amount of direct reflection from the surface of the courts, and one would hardly hope to secure such a strong contrast as the above in all parts. If the surface brightness of the near and distant portions of the court is measured, one is sometimes struck by the increased brightness due to direct reflection of the more distant regions. This attains 0·3 foot-candles in some parts when viewed from some directions, but only a little over 0·1 in others. An attempt was made to estimate the average contrast between the white balls and the black court surface; this appeared to be of the order of 10 : 1. The contrast between the white lines of the court and the dark intermediate surface is very similar.

An interesting attempt was also made to compare the contrast secured by using red and white balls respectively. At one stage in the erection of the courts experiments with red balls were made, the idea being that although these are somewhat darker than the white the vivid colour might prove a more than compensating advantage.

The white balls, however, proved much the most satisfactory. Mr. Rootham demonstrated this for our representative's benefit by throwing up a red and white ball into the air simultaneously. At a certain point in the flight the red ball appeared to vanish, but the course of the white ball could still be followed to the end. A test with the Holophane Lumeter showed that the contrast of the red ball and the court surface was about 5 : 1—only half the range secured with the white ball. This is probably the explanation of the greater ease with which the white ball can be seen.

On the average it would seem that the surface brightness of the court surface varies from about 0·15 to 0·3 foot-candles, that of the walls being usually about 0·1, and that of the white ceiling 0·3.

The illumination at the table in the entrance hall and the Hon. Secretary's office was also measured and found to be about 6 and 3 foot-candles respectively.

FIG. 2.
Showing view of tennis courts from below (taken entirely by artificial light).

FIG. 3.
Showing court and nature of sources, as seen from the gallery (taken entirely by artificial light).

Photographs by Artificial Light.

The two illustrations on p. 277, taken from the floor and the gallery respectively, give an excellent idea of the nature of the interior, and the method of grouping of the lamps. They are obtained from photographs taken by artificial light on the spot, and are not retouched in any way. The success obtained at the first attempt, in showing both the illuminated courts and the actual luminous sources, is largely due to the fact that the exposure was based upon measurements of the surface brightness and the various objects.

In passing, it is interesting to add that an attempt was made to gain an approximate idea of the actual brightness of the ground glass plates beneath the mantles. This appeared to be of the order of 100 foot-candles near the edge and rather over 1,000 near the centre; the range of brightness included in the photograph is therefore very considerable. In judging, the exposure on the floor of the surface of the courts was regarded as the most important item and the exposure was regulated accordingly. In the photograph taken from the gallery the lamps themselves were regarded as the main object to be brought out, and with this view a considerably shorter exposure was given. It is interesting to see how clearly the cone of light focussed downwards by the reflector is brought out.

Conclusion.

In conclusion a word of thanks is due to the members of the staff of the S. Metropolitan Gas Co., who very kindly explained the working of the plant and gave full information regarding the installation.

Special acknowledgment must finally be made of the courtesy of the architect of the building, Mr. H. M. Rootham, B.Sc., A.M.I.C.E. (who, being himself keenly interested in the game, was in a specially favourable position to meet the peculiar problems presented, and explain the features of the installation), and of Mr. P. W. Rootham, the Hon. Secretary of the Club, of 93, South Croxted Road, Dulwich, in granting permission for measurements to be carried out and photographs taken of this unique installation.

The Value of Reflectors.

Some particulars of the effect of reflectors in improving the light from incandescent lamps, are given by Mr. T. W. Rolph in *The Electric Journal* (Pittsburg), and abstracted in a recent number of *La Revue Électrique*. Apart from the protection against glare which is afforded by reflectors, the gain in light emitted, especially in certain directions, is very great. The following table gives some idea of what may be obtained :—

Source of Light.	Flux of Light (in lumens). Angle from the Vertical.			Percentage increase. Angle from the Vertical.		
	0°–60°	0°–45°	0°–15°	0°–60°	0°–45°	0°–15°
60 watt Tungsten Lamp, without reflector	86·8	11·6	3·1	—	—	—
" " " with intensive reflector	221	154	20·3	155	270	536
" " " with focussing reflector	223	170	32·0	157	308	903

TRANSACTIONS
OF
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The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Interior Illumination and the Reflecting Power of Walls and Ceilings.

(Proceedings at a meeting of the Illuminating Engineering Society, held in the House of the Royal Society of Arts (London), on Monday, April 24th, 1911.)

A MEETING of the Society was held on April 24th, MR. R. J. WALLIS-JONES occupying the chair in the unavoidable absence of the President.

The minutes of the last meeting having been read and confirmed, THE CHAIRMAN called upon the HON. SECRETARY to read the names of applicants for Membership received since the last meeting, and also to read again the names of those presented at the previous meeting on March 14th, who would now formally be declared members of the Society.*

A letter was then read by the HON. SECRETARY from the British Executive Committee of the International Hygiene Exhibition to be held at Dresden this year, in which an invitation was extended to the Illuminating Engineering Society to co-operate in getting together exhibits connected with illumination, and to assist the committee by advice, &c.

The HON. SECRETARY also read a letter from the Secretary of the Royal Sanitary Institute inviting the Illuminating Engineering Society to appoint delegates to the 26th Congress and Exhibition, to be held in Belfast in July. THE CHAIRMAN suggested that the names of any members willing to take part in connexion with either of the above events should be sent in to the HON. SECRETARY as soon as possible.

MR. HAYDN T. HARRISON was then called upon to read his paper on 'The Ratio of Light to Illumination,' and MR. P. J. WALDRAM followed with 'Some Notes on the Effect of Wall-papers on Illumination.'

In the discussion which followed MR. A. P. TROTTER, MR. J. ECK, MR. V. H. MACKINNEY, MR. T. E. RITCHIE, MR. J. G. CLARK, MR. W. R. RAWLINGS, and MR. J. HEWETT took part.

MR. HARRISON and MR. WALDRAM briefly replied to some of the points raised in the discussion, and THE CHAIRMAN, after making a few comments on the papers, proposed a hearty vote of thanks to these gentlemen for so ably opening the discussion.

The annual general meeting was announced by THE CHAIRMAN to take place on May 9th, and the members then adjourned to the Library, where tea and coffee were served.

Annual General Meeting.

Readers are reminded that the **Annual General Meeting** of the Society will take place on **Tuesday, May 9th**, at 8 P.M., at the House of the Royal Society of Arts (John Street, Adelphi, London, W.), when the Report of the Council for the past session will be presented.

It is hoped that all members will make a special effort to be present.

* See p. 289.

The Ratio of Light to Illumination.

By Haydn T. Harrison, M.I.E.E.

(Paper read at the meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Monday, April 24th, 1911, at 8 P.M.)

Only within the last few years has artificial illumination been dealt with as a separate science; therefore it is not surprising that some of the terms connected with it are often used with different meanings, thus leading to confusion.

The very title of this paper would confuse many who are in the habit of looking upon light and illumination as the same thing; but I prefer to treat the definition of light as that which causes illumination, whether that illumination is visible or not.

I agree, for instance, with Mr. Trotter's definition of illumination as depending simply on the quantity of light falling upon a surface, and that it has nothing to do with the colour or reflecting value of that surface. Therefore, it would be, strictly speaking, inaccurate to state that an instrument (such as the Holophane Lumeter used by Mr. Waldram for the valuable tests of which the results will be put before us by him to-night) indicated the illumination except when it was pointed at a white screen of similar material to the screen in the instrument itself and which is illuminated to a pre-determined degree.

In order to demonstrate my point I carried out the following experiments with my "Universal" photometer as made by Elliott Bros. As you are aware, this instrument consists of a screen capable of angular displacement, thus varying the degree to which it is illuminated by a standard lamp. This screen is used in conjunction with the Whitman sector flicker disc, and thus indicates the degree of illumination derived from a source of which the candle-power value can be calculated. The advantage of using this instrument was that, by replacing the standard comparison screen by the various tinted wall-papers which Mr. Waldram used in his experiments, I could ascertain very accurately the increased illumination necessary in order that the rays reflected from such wall-papers should have the same effect on the eye as when a white paper of similar surface to the photometer screen was used.

As the results of my experiment may be interesting I give them below:

Screen No.	Colour.	Increased Illumination necessary.
1.	Bright red	3·5 times
2.	Dull cardinal red	6·5 „
3.	Medium blue	4·8 „
4.	Light blue	3·2 „
5.	Dark green	7·0 „
6.	Light green	2·2 „

Another interesting point that these tests proved was that the angle of incidence of the light rays closely followed the cosine law over the greater part of the angular movement, despite the fact that the surface of these wall-papers was far from a plain one.

My next experiment was to ascertain the value of the light reflected from the area of these papers compared with that of white blotting paper, and I found that, though these tests were made under very different conditions and very roughly, owing to the short time available, they to all intents and purposes corroborated the figures given above, thus proving that an instrument of the Holophane Lumeter class measures correctly the irregular reflecting value of a surface.

Mr. Dow and Mr. Mackinney, when describing their "Holophane Lumeter" instrument in the *Illuminating Engineer* (May, 1910), stated that it could be used to measure either intrinsic

brilliancy expressed in terms of candles per square centimetre, or illumination expressed as Lux or foot-candles "which a truly white surface would have to receive in order to have an equivalent brightness."

This description is quite correct, except that it might be taken to mean that the instrument indicates either intrinsic brilliancy or foot-candles, thus making it appear that they were one and the same thing. This, of course, is not so, therefore it must be clearly understood that it only measures foot-candles when a special screen is used.

It is interesting to note here a remark of Mr. Trotter's, viz.: "Such terms as illumination, brilliancy, brightness, intensity, and luminosity are generally employed by different writers to express different ideas, and are often used in a confused, vague way." This, unfortunately, is as true to-day as when it was written, therefore it is not surprising that it is difficult to fix definitely a unit which accurately describes reflecting value, and I doubt whether a better word than "Luminosity" could be chosen. Sir William Abney describes luminosity as brightness resulting from illumination, which is exactly what the Holophane Lumeter measures. But in this case are we to regard "luminosity" as denoting luminous flux per unit area, so that it would be expressed, say, in lumens per square inch? Or as denoting C.P. per unit of area?

With regard to the other terms, personally I use them in the following sense:—

1. *Light.*—The emanations from a light source.

2. *Illumination.* — The extent to which anything is illuminated; Foot-candles.

3. *Brilliancy.* — Refers to primary light source and is candle-power divided by area.

4. *Intrinsic Brilliancy.* — Candle-power per unit surface (sq. centimetre).

5. *Brightness and Intrinsic Brightness.*—Same as brilliancy.

6. *Luminosity or Luminous Intensity.*—Same as brilliancy, but applied to secondary sources of light.

I only put the above table forward as suggestive, and would like to see the terms "brilliancy" and "brightness" always applied to primary light sources, as considerable confusion, which is now caused by their indiscriminate use, would be obviated.

For example, many people talk about a bright light, and this under the above classification would be correct; but for an artist to talk about a bright colour would be incorrect. But, on the other hand, an artist and a colourman think on different planes: a colour is bright to an artist under one condition and dull under another, whereas to a draper or a colourman a colour is *ipso facto* a colour describing something when viewed under normal light, and he would not grant that the colour is changed when viewed under an abnormal light, but that the light is changed. Therefore, the luminosity is changed, whereas illumination is not changed by the fact that it falls and is reflected to the eye in a varying degree dependent on its colour.

If luminosity or luminous intensity is used as applied to indirect or secondary sources of light, the value of these sources could be stated in lumens instead of candle-power, which would simplify matters considerably. For example, if we could state that any given area in a room was illuminated to a certain degree in foot-candles by direct light from a source plus so many lumens in the form of indirect illumination, we should know at once the relative reflecting value of the surroundings of the light source, and also the likely density of the shadows. This would not be a difficult thing to measure, as, by shading the direct light from the measuring surface, we get the illumination due to the lumens (indirect lighting) only.

Louis Bell points out that altering the position of the primary source of light in a room does not affect the illumination seriously if the walls and ceiling diffuse strongly (*i.e.*, have a high degree of luminosity), while, if they are dark, the change is decidedly unfavourable. I will go further than this and say that if the walls and ceiling have a 100 per cent luminous efficiency and the light, though invisible, is placed

so as to illuminate them, the resulting illumination will have a maximum efficiency. On the other hand, if the walls and ceiling have no luminous efficiency and no direct illumination is derived from the source of light, the illumination will be zero. The various stages between these two limits will be inversely proportionate to a table similar to that given in the early part of this paper. If this theory is correct, the illumination at any part of the room will be proportionate to the direct illumination plus the illumination due to light reflected from the surfaces visible from the point of measurement.

The measurement of the illumination derived from all sources is of course an easy matter, such instruments as the Trotter photometer, Holophane Lumeter with subsidiary screen, and several others, being available for the purpose; but to ascertain the light value of the original source of such illumination is a very different thing.

The importance of ascertaining this light value arises when a question of cost and efficiency is under consideration, and the only satisfactory method is either to eliminate all reflecting sources or to remove the lamps to the test-room. In either case the question presents itself as to what is the light source—is it the lamp only, or the lamp plus the globes and reflectors, which may considerably enhance its value as an illuminating agent?

It must be borne in mind that globes and reflectors only enhance the lamp's value as a light source for the purpose of giving direct illumination, and often depreciate its value from the point of view of the reflected illumination derived from the surrounding objects. Therefore, the value of the naked lamp alone must be known, and this is of course easy to ascertain by the usual photometric methods. The value of such a lamp plus globes or reflectors is a more complicated matter, owing to the area of the light source being increased and thus interfering with the square law of photometry. Under these circumstances, unless means are available for obtaining the profile curve of lighting, the only way to ascertain the illuminating value of a light source, including reflector, &c., is by ascertaining the illuminating results.

For this reason I would suggest that all makers of lamps who wish the apparatus supplied by them to be used to the best advantage should accurately state the candle power derived at various angles, and should not be content with stating either the maximum, horizontal, or mean spherical or hemispherical candle-power. If makers would do this, the lamps or combinations of lamps with globes and reflectors would be divided into classes, which would not only greatly assist illuminating engineers, but would result in the goods supplied being used to the satisfaction of the public.

This naturally leads to the consideration of the relative merits of lights with reflectors or globes which increase the illumination in the direction required, versus unprotected lights from which good illumination is obtained by using the walls or ceiling as reflectors.

It is obvious that as regards efficiency the use of reflectors will generally have the advantage. Take, for example, a room with white ceiling and walls. The upper hemispherical rays are reflected back into the room and usefully increase the illumination, but, on the other hand, a reflector placed directly over the lamp, provided it receives all the upper hemispherical rays, will even more efficiently direct them on to the remainder of the room where illumination is required, but will leave the upper part of the room in comparative darkness. In the case of a room which has not a white ceiling and wall-paper the efficiency of a reflector will be comparatively higher, and, what is even more important, will remain constant owing to the fact that it can be cleaned more often than it is convenient to whitewash the ceiling and walls of a room. But the physiological (light sensation) effect is different, because the illumination is derived from a single source, while in the other case it emanates from all directions.

I am prepared to grant that a person entering a room with light coloured

ceiling and walls will often state that it is better illuminated than a similar room where the surroundings are dark coloured. Nevertheless, the illumination in the latter case may be better than in the former, and possibly the physiological effect would eventually prove more generally satisfactory as the high luminosity of the surroundings would tend to close the iris, thus producing a trying effect on the optic nerve if an attempt to work is made under those conditions.

This is where the province of an illuminating engineer becomes very similar to that of a physician. The latter cannot always tell the effect of the drugs he prescribes on various people, and often has to use the trial and error method; so the illuminating engineer will have to learn the effects which are most likely to please his clients.

For example, very few men would like to work in a study or dine in a dining-room where the light emanates from all directions and where the iris of the eye is kept constantly contracted by the high luminosity of the surroundings. On the other hand, many of the opposite sex would prefer it, owing, I fancy, to their desire to exhibit themselves and their costumes. Nature, however, tones down the luminosity of surroundings as the brilliancy of the sunlight increases, by providing them with a covering of green which is restful to the eye.

Artists have learnt that in order to depict high illumination they must have strong contrasts, such as the deep shadows provided by nature, and I think in this respect they teach illuminating engineers a lesson. Shadowless illumination is always depressing, just as a day when the sun is obscured by clouds is depressing; and I think it would be wise to deliberate carefully before any system of shadowless illumination is adopted, and to remember that the object of all illumination is to produce an effect by which the outlines of objects are easily seen, which result is greatly assisted by the effect of light and shade.

In conclusion, I must apologize if this paper is not what the title and synopsis in your Journal led you to suppose it would be. I am afraid it comes to little more than the stringing together of a few matters that interest us all. Nevertheless, if it provides food for thought and eventually results in some of the ambiguities I have touched upon being cleared up either by subsequent papers of discussions, I am sure you will forgive me for having placed before you these few remarks, not on the score of their merit, but on account of what they may produce.

Some Notes on the Effect of Wall Papers on Illumination.

By P. J. Waldram, F.S.I.

(Paper read at the meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Monday, April 24th, 1911.)

When one considers the enormous development of gas and electric lighting industries throughout the world, it seems strange that few exact rules should exist which would enable any given degree of illumination to be predetermined from illuminating units of given candle-power distribution.

Still more strange does this appear in view of the large army of consulting electrical experts whose chief business it is to specify the number and candle-power of illuminants which will give satisfactory illumination under given conditions.

The problem is one which comes constantly — almost daily — before every one connected with the huge modern industry of artificial lighting, from the officials of the great supply companies down to the small builder or the village gasfitter. But it would be difficult to find any one who could say what illumination on a table or desk could be expected from illuminating units of given candle-power

distribution in the presence of walls and ceilings of given colours. The architect, whose efforts will to a large extent be made or marred by the results of the lighting installation, and the householder who has not only to endure the results of any mistakes but to pay for them, both have the doubtful pleasure of knowing that the knowledge upon which they are forced to rely is still largely guesswork.

A large amount of labour and research has been devoted to determining with great exactness what flux of light is emitted in different planes by different units of illumination; but it is difficult to apply such knowledge to practical problems of illumination because the important factor of reflection and counter reflection from walls and ceilings has been neglected or shirked on account of its real or supposed difficulty. It is no exaggeration to say that very few experts could say whether this factor in any given case will increase the total illumination by 10 per cent, by 50 per cent, or by 100 per cent.

A not unusual way out of the difficulty is to calculate the direct flux only, leaving any increase due to reflection to make up for subsequent deterioration in lamps. This would be reasonable if one had even an approximate idea of the relative values of the two. As an excuse for almost complete ignorance it is apt to appear to the architect or his client a trifle thin.

It is moreover a direct temptation in cases where economy is of importance, to specify those shades which tend to concentrate the rays of light into a given specified working plane, leaving the walls and ceilings objectionably dark, and leaving the working plane under the disadvantage of a strong undiffused light, very liable to cause shadows and glare from glazed surfaces. The secret of all successful artificial illumination is to approximate as closely as we can to those conditions of daylight under which our eyes have developed; and the property which all artificial illuminants lack is diffusion.

Our eyes accept without protest huge differences in range of daylight because it is so perfectly diffused by the enormous depth of atmosphere through which it must pass; but a difference of even two or three foot-candles in artificial illumination will cause considerable inconvenience.

As Mr. Harrison has pointed out, shadows, which are distinctly restful to the eye in daylight, are similarly beneficial in artificial lighting. But shadows, or rather differences in the intensity of an otherwise objectionably uniform light, can be obtained by providing surfaces within the range of vision which reflect different proportions of light.

Optically, therefore, it would appear that the correct policy is to utilize as fully as possible the reflecting and diffusing properties of walls and ceilings, and to afford relief from trying uniformity by the use of coloured surfaces, in positions where they will catch the eye without unduly reducing the efficiency of the installation.

A successful scheme of artificial illumination would seem to demand collaboration between the architect and the lighting expert at an early stage in the design. But architects are by way of being fairly shrewd (popular ideas notwithstanding), and they are not likely to vary their designs or their schemes of decoration unless the lighting expert can base his requisitions upon exact knowledge—and can answer pertinent questions thereon. The more, therefore, we can ascertain about the subject and the less we have to trust to guesswork the better.

What is expected of any scheme of artificial illumination is as follows:—

1. That the working or table plane of the room shall receive an equable light, as much diffused as possible, sufficient for the purposes for which the room is to be used without being excessive.

2. That the walls and ceilings should receive and reflect such an amount of light that they appear to be neither too glaring nor too dull, with all essential architectural features brought into sufficient prominence.

Up to the present it has been customary to more or less neglect the wall and ceiling illumination and to con-

sider the working plane illumination as being a criterion of the whole. This is not only wrong, it is injudicious. An interior may have an excellent illumination on the table, but not one person in a hundred would give it credit for being a well-lit room on that account. The walls are what practically every one unconsciously judges by. According as they are bright or dull, warm in tint or cold, so, rightly or wrongly, the illumination of the room is popularly classed. The light reflected by the walls and ceilings has a psychological effect upon those who use, judge, and pay for it which neither the architect nor the lighting expert can afford to disregard. The term psychological effect is unusual in this connexion; but the effect of horizontal aspect upon our visual judgment is something more subtle than the physiological effect on the iris.

Commercially, too, the reflected light from walls and ceilings is important. Gas or electricity is sold and bought in order that a certain amount of light shall be reflected into our eyes from objects which must be viewed under artificial light, but lamps and mantles emit light in all directions, and users ought to understand that a large proportion of light which falls upon walls and ceilings of poor reflecting capacity is absorbed permanently, and represents money thrown away without any result.

It is also in the best interests of those who sell illuminating energy or the means by which it is utilized to be in a position to point out to their customers that buying light in order to feed the capacious appetite of, say, dark red or olive green papers with that expensive commodity is hardly conducive to satisfactory results. The best and cheapest advertisement is a satisfied customer. A dark-walled room with a dull ceiling will not only always look dull but also will actually be decidedly more expensive to light than a similar interior possessed of better reflecting surfaces. Light walls not only impress the user, they also assist very materially to actually illuminate the ceilings, the table planes, and themselves. Considering that rooms can be lit entirely by reflected light from the ceiling and walls, with an almost entire absence of shadow, it is obvious that ignorance of the value of such an important factor is almost inexcusable. There is a need for recognized standards of surface brightness which will be satisfactory for different classes of interiors, and the author ventures to suggest that the Council should take steps to establish such standards.

The predetermination of interior illumination is at first sight by no means an easy problem. The proportion of light thrown upon walls, table, and floor is subject to variation with every alteration of shade and height of lamp. Then the ceiling reflects not only on to the table and floor, but also on to the walls, which, in turn, reflect partly on to the floor and partly back to the ceiling; and all these incidents of reflected light are reflected again and again until the mind refuses to grasp further complications.

But however complicated reflection may be, its total *effect* at any point can be ascertained by simply screening off any direct rays previously incident on that point from the light source. If such results were obtained, averaged, and recorded for a sufficiently large number of interiors and conditions, there would be little difficulty in determining, at least approximately, what reflected illumination might be expected from any given flux of direct light on walls and ceilings of different colours and textures.

If for any situation the direct flux were calculated from the candle-power distribution curve, the indirect or reflected flux deduced from results obtained under similar conditions, and the surface brightness of the wall surfaces ascertained by multiplying the flux direct and indirect incident upon them by the coefficient of reflection of their colour and texture, then the essential conditions of interior lighting could be satisfactorily predetermined.

Reflection-coefficients.—A very exhaustive table of the reflection coefficients of various wall papers has been prepared by Dr. Louis Bell, and

will be found in a paper read by Mr. Leon Gaster before the Association of Engineers in Charge (London), on December 11th, 1907.

The author is not quite clear as to how these coefficients were arrived at,

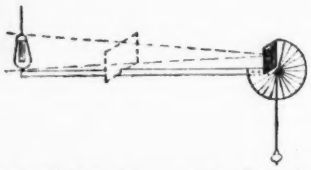


FIG. 1.—Sketch of apparatus for determining polar distribution curves.

but he suggests that the reflection coefficient for any paper, colour, or texture can be ascertained with sufficient accuracy for all practical purposes by measuring its apparent surface brightness in a direction normal to its surface as compared with that of white blotting paper, a Holophane Lumeter standard card, or any other suitable standard under the same illumination. The reflection coefficient of some papers appears to vary with the angle of reflection, but this is a case where half a loaf is preferable to starvation, and it is better to start with data which may require subsequent refinement as our knowledge increases than not to start at all.

It is interesting to note that Mr. Harrison obtained the same values whether the reflection coefficients of different papers were measured by means of the irapparent surface-brightness or their capabilities of emitting reflected light as secondary illuminants.

C.P. Distribution Curves.—Candle-power curves of lamps and shades are not used at the present time to anything like the extent which they ought to be and to which they would be were it possible for the lighting expert to obtain them readily for any combination of lamp and shade. It is from the c.p. curve, and from it alone, that he can determine what direct flux of light will fall upon any given position even if he neglect the enhancing effect of walls and ceilings.

It is, however, no small matter to place a lamp and its shade upon a photometer bench and test it at all angles; and if it were possible to obtain a fully accurate curve from a lamp and shade either in actual use or fixed temporarily to a point, doubtless they would be used more largely. The author suggests the following method as being simple and sufficiently accurate for practical purposes.

To one end of a light wood lath (Fig. 1.) is fixed a vertical bent plate of tin blackened and marked in degrees and carrying a plumb bob so that the angle with the horizon at which the rod is being held can be at once read off. Part of the tin plate is bent at right angles to the direction of the lath, and a plate of known whiteness—white blotting paper or a Lumeter test-plate—is attached by means of a rubber band. A blackened brown paper screen is held or hung behind the lamp and shade to be tested, the lath is held with the point just touching the lamp. The illumination in foot-candles produced on the test-plate is then read, with

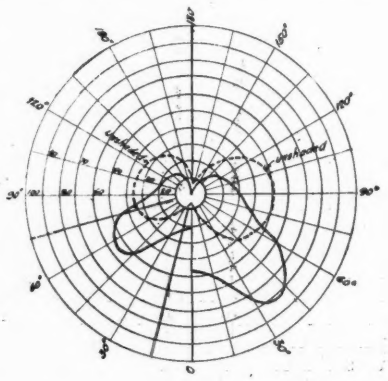


FIG. 2.—Polar distribution curves. Left-hand curves for 35 watt Mazda lamp in E shade (lath test); right-hand curves for 55 watt Osram lamp in E shade (laboratory test).

the lath held at different angles. This illumination (except in a blackened room) is produced partly by the lamp and partly by reflection from surroundings, or even by other lamps. The

rays coming from the lamp alone are isolated from the extraneous light as follows. A small black screen of such a size as to just screen all the rays from the lamp and shade, but nothing else, is held in a notch in the lath, and a reading taken under these conditions represents the extraneous light only. The difference between the two represents the direct rays from the lamp and shade only. The net foot-candle readings divided by the square of the length of the lath used give the required candle-power at various angles. The method seems somewhat rough, but it is very handy, and gives curves which approximate very closely to those obtained in the laboratory. Fig. 2 shows two distribution curves of similar lamps in similar shades, one obtained in the laboratory and the other (of smaller power) obtained with the lath. It also enables curves to be measured for gas mantles, oil lamps, wax candles, &c., which are very difficult to obtain in any other way. By its means the difference caused by various patterns of shades can be quickly tested; and it should not be forgotten that many people who are only confused by figures and technical terms will readily grasp the meaning of a curve.

Equipped with the distribution curve of the particular light unit or units which it is proposed to adopt, and the reflection coefficient of the wall and ceiling papers or colours, the installing engineer can say what direct flux of light will fall upon the walls, ceiling, and table plane of any room, and what will be the surface brightness due to that flux. All he requires to know is what increase in the flux will be due to reflection.

A very exhaustive series of tests on this point was carried out by Drs. Sharp and Millar in America last year in a room about 12 ft. by 12 ft. by 10 ft. high, but with a powerful pendant lamp near the ceiling. The walls were "greyish-white," the ceiling white, and the floor brown linoleum. The results obtained will well repay study. (See Trans. American Soc. Ill. Eng., May, 1910.) Briefly summarized they are as follows: the lamp used directed an average flux of 1·20 foot-candles on to the ceiling, 2·50 foot-candles on to the walls, and 1·25 foot-candles on to a table plane 3 ft. from the floor.

It was found that the total effect of reflection and counter reflection from walls and ceilings *under these conditions* was equivalent to an average secondary flux of 1·90 foot-candles on the walls, 0·65 foot-candles on the ceiling, whilst the illumination on the table plane was doubled to 2·5 foot-candles.

This test, excellent as it is, gives only the results for one size of room, one scheme of colour, and one scheme of lighting. What we require are more numerous (if less detailed) results obtained in a number of rooms of different sizes with different schemes of colour and with varying proportions of light thrown upon walls, ceilings, and floor respectively by means of light units at varying heights with various shades.

Tests of Effects of Wall Papers in a given Interior.—The author hoped to have been in a position to submit to the Society the results of a number of such tests of different rooms. Although, owing to illness, he has been unable to complete them, a description of their scope might possibly induce others to collect data on the same or better lines.

The method adopted was to divide the floor, walls, and ceilings into a number of equal rectangles. The c.-p. distribution curves of the lamps having been measured as before described, readings were then taken with an illumination photometer of the illumination received by a detached test-plate placed in the centre of each rectangle. Then another series of readings was taken with a small black screen placed about halfway between the test-plate and each lamp, so as to just cut out the direct lamp rays whilst obliterating as little as possible of the light reflected from the ceiling. This second set of readings isolates the increase due to all reflections and counter reflections for that size of room and colour of wall and ceiling surfaces, and the difference between the sets of readings should equal the direct flux as calculated from the c.-p. curves.

A room about 19 ft. by 12 ft. 3 inches by 10 ft., papered with very dull red paper possessing a coefficient of reflection of only about 11½ per cent was temporarily fitted with two 35 Watt Mazda pendant lamps and tested with different Holophane shades varying the incidence of the light rays. The walls were then altered from such an approximately worst condition to an approximately best by covering them temporarily with white lining paper with a coefficient of reflection of 100 per cent, and similar readings were taken. In order to study the separate effect of wall and ceiling reflection in the table plane a plan of that plane

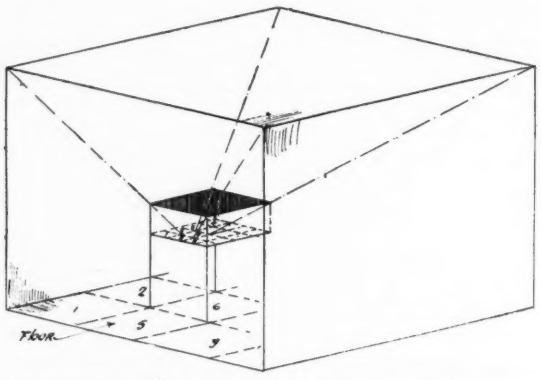


FIG. 3.—Diagram of room showing test plane and light screen.

was made and divided into a series of similar rectangles, the centre of each being a test station. A cardboard fence to the same scale was also made as in Fig. 3. When the plan was placed on any test station, the fence placed round it, and the test card laid on the corresponding rectangle, then the test card was exactly shaded from any reflected light from the walls and received only the reflected light from the ceiling.

The ceiling was similarly screened off by a canopy to scale with open sides which admitted all the reflected light from the walls, but cut off that from the ceiling. It is proposed to compare the results thus obtained with a series of tests which, I understand, is now being made by Holophane, Ltd., in a smaller room hung with a series of different coloured papers. The Holophane tests should be of great value when completed. As far as the author's results have been carried it would appear that under average conditions the increase of flux of illumination on walls by reflection tends to vary somewhere from between 50 per cent and 70 per cent with white wall paper down to between 20 per cent and 30 per cent with very dark papers. The increase of flux of illumination on white ceilings appears to be in about the same proportion as on the wall papers to which they are adjacent. The increased illumination on table planes in foot-candles appears to be about a mean between the increases in foot-candles of the flux on the walls and on the ceiling.

These results are of course very approximate, and they are only put forward as practical terms in which it may be found possible to express the results of future investigation.

As an example of the use to which they might be put, the case of a public dining room, 45 ft. by 30 ft. by 15 ft. high, might be taken. Using the ordinary Holophane E shades and data, the installation would probably be six pendants of about 110 candle-power each. From the distribution curve of such lamps and shades it

would be found that the average flux of light on the table plane would be about 3foot-candles; on the walls, at the critical height of 5 ft. 6 in., about 2 ft. candles, whilst the average flux on the walls would be about 1 foot-candle, and on the ceiling 0·5 foot-candle.

The paper would probably be quite dark, reflecting only about 10 per cent to 15 per cent of the flux. Then if the foregoing approximate conclusions were found to be correct, we should expect the average illumination on the walls to be increased to, say, 1·3 foot-candles; at the particular height of 5 ft. 6 in. to 2·3 foot-candles; on the ceiling to 0·6 foot-candles; and on the table plane to 3·25 foot-candles. The average apparent brightness of the walls would therefore be 0·13 to 0·2 foot-candles, and, at the critical height of 5 ft. 6 in., 0·23 to 0·3 foot-candles—if anything perhaps a trifle too bright for a dining-room. This would probably be altered by lowering the lamps.

[We propose to publish the complete discussion of these papers in our next number.—Ed.]

New Members of the Society.

The names of the applicants for membership, read out at the previous meeting on March 14th, were formerly announced for the second time at the meeting of the Society on April 24th, and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were also read out by the Hon. Secretary :—

Members.

Corin, W.	Chief Electrical Engineer, Public Works Department, SYDNEY, New South Wales.
Greenslade, C. E.	Instructor in Electrical Engineering, Crawford Technical Institute, Cork, IRELAND.
Merrett, J. A.	Consulting Engineer, 65, Nevsky Prospect, St. Petersburg, RUSSIA.
Morgan, H. E.	Inspector, South Metropolitan Gas Co., 12, Camden Avenue, Peckham, London, S.E.
Peschke, Max	Electrical Engineer, Steinmetzstrasse 63, Berlin.
Thomson, Alex., Jr.	Electrical Engineer to the Union Electric Co., 8, Hamilton Park Terrace, Hillhead, Glasgow.

* See *Illum. Eng.*, Lond., April, 1911, p. 217.

Notes on the Illumination in Various London Schools and Colleges.

BY LEON GASTER AND J. S. DOW.

(Presented at the adjourned discussion of the Illuminating Engineering Society on Schoo lLighting, held at the House of the Royal Society of Arts, London, on March 14th.)

(*Concluded from p. 216.*)

SOME FIGURES IN GERMAN SCHOOLS.

It also occurred to the authors that it would be of interest to collect, and transfer into British units, some data regarding Continental schools. As an example of these we have reproduced Table III., which is taken from Bloch's Grundzüge der Beleuchtungstechnik (p. 124), and Table IV.

The most striking points to be observed are the relatively high illumination and the good uniformity of the results obtained. On the other hand, the consumption per square foot of floor area does not seem noticeably different from that usually met with in this country.

In this connexion it is of interest to make passing reference to the work

of Dr. Max Oker-Blom, of the University of Helsingfors, Finland (*Int. Archiv. f. Schulhygiene*, Jan., 1911), to which Dr. Kerr kindly drew our attention. Artificial lighting is of special consequence in this locality in view of the short winter days. Thus Helsingfors on January 15th only receives 6 h. 40 min. of daylight, and Sodankylä 3 h. 32 min., while in Utsjoki the sun does not rise at all for two months. The author referred to describes a series of experiments, using direct lighting with different opal shade and a clear bulb metallic filament lamp, as shown on the left of the diagram.

This is almost always unsatisfactory, because the filament is imperfectly shaded, and therefore, when the lamps are placed more or less in the direct range of vision, dazzling to the eye. A better arrangement is that shown immediately below, completely frosted lamps being used. It is employed at Harrow, in the newer rooms at the Northampton Institute, &c. By completely frosting the lamps the glare is

TABLE III.—ILLUMINATION IN SCHOOLROOMS IN GERMANY.

[Based on figures derived from data presented by the Münich Commission and other authorities, and tabulated in Grundzüge der Beleuchtungstechnik (L. Bloch), p. 124].

Nature of Lighting.	No. of lamps.	Power consumed per lamp.	Floor Area (sq. feet).	To al watts per square foot (approx.).	Total watts per sq. foot per foot-candle.	Illumination in foot-candles. Mean	Max.	Min.	Diversity Co-efficient. Max. / Min.
Electric.		*Watts.*							
D.C. Arc Lamps Vertical Carbons	3	770	1700	1·35	0·23	5·7	6·9	4·6	1·5
	2	550	780	1·4	0·27	5·2	7·0	3·5	1·95
	2	605	1040	1·2	0·21	5·7	—	—	—
	4	540	1650	1·3	0·32	4·0	5·5	2·45	2·2
	2	550	780	1·4	0·33	4·2	5·8	2·45	2·4
D.C. Inverted Arcs	3	735	1700	1·3	0·15	8·9	11·2	6·7	1·7
	3	715	1700	1·25	0·155	8·0	9·7	6·3	1·55
	2	650	780	1·7	0·245	6·9	11·0	3·6	3·0
		Consumption in cub. ft. per hour per lamp.		Total consumption cub. ft. per hour per squ. foot.	Total consumption cub. feet per hour per squ. foot per foot-candle.				
Gas.									
Low Pressure Incl.	52	3·8	1700	0·.2	0·016	7·4	8·6	6·0	1·4
	14	4·2	1040	0·06	0·0145	4·1	—	—	—
High Pressure (Selas)	10	13·2	1700	0·08	0·011	7·0	8·0	6·1	1·3
High Pressure (Millenium)	8	17·1	1700	0·08	0·0115	6·9	8·5	5·8	1·45
	6	8·6	840	0·06	0·0095	6·2	6·7	5·3	1·25

groupings of lamps. He presents half-tone illustrations of the hand shadows on the desks in various parts of the room; there were almost invariably some desks on which inconvenient shadows were cast.

TYPES OF FIXTURES MET WITH.

In Fig. 7, a number of types of shades met with in various schools are collected together. The commonest arrangement consists in the use of the ordinary diminished, but a considerable amount of light is lost; moreover, even a frosted lamp, when hung somewhat low, is probably inconvenient to some extent. A preferable type of shade seems to be that now used by the London County Council, and in use at Haverstock Hill, at the Arts and Crafts School, &c. This completely screens the lamp, which need only be half frosted.

One distinctly peculiar arrangement

is the bunch of unshaded clear bulb lamps used in the Science Buildings at Dulwich College.

The design of shades for gaslighting has been dealt with by Dr. Herman. In this case also it is desirable that the mantle should be completely screened from the eye. Except for the loss of light involved, the opal bowls used at Dulwich College are satisfactory. The rooms lighted in this manner have a pleasant "soft" appearance, but the illumination, as stated, was somewhat low. At the East London College the illumination is supplied by Holophane glassware, reflector bowls, hung high up, being used in the Lecture Theatre with very satisfactory results.

TABLE IV.—ILLUMINATION IN VARIOUS ROOMS IN THE TECHNISCHE HOCHSCHULE, MUNICH.

(Report of the Commission appointed by the Deutsches Verein von Gas- und Wasserfachmännern, 1907.)

Nature of Illumination of School Room.	Illumination on Desks. (Foot-candles.)			Diversity co-efficient max. / min.
	Max.	Min.	Mean.	
Incandescent gas, semi-indirect ...	2·6	2·0	2·3	1·3
Electric Arc lamps (3 in series), semi-indirect	4·7	1·6	3·1	3·0
Electric arc lamps (2 in series), semi-indirect	4·1	1·5	2·8	2·7
Incandescent gas, indirect	8·6	6·0	7·3	1·4
Selas incandescent gas, indirect ...	8·0	6·0	7·0	1·3
Selas incandescent gas, indirect ...	7·3	5·2	6·2	1·4
Selas incandescent gas, indirect ...	9·0	6·2	7·6	1·45
Millennium incan. gas, indirect ...	8·5	6·0	7·2	1·4
Electric arc lamps, indirect lighting, ordinary carbons	7·0	4·6	5·8	1·3
Electric arc lamps, indirect lighting, inverted carbons	11·1	6·7	8·9	1·65
Electric arc lamps, indirect lighting, inverted carbons	9·6	6·3	7·9	1·5

N.B.—It may be noted that this Commission seems to have been of a very representative character, receiving the assistance of Herr Arzberger, Chief Engineer of the Münich Gas Works, Dr. Schneider, an oculist in Münich, Herr Utzinger, Chief Engineer of the Siemens-Schuckert Co., and others, and the co-operation of the Münich Institute of Hygiene.

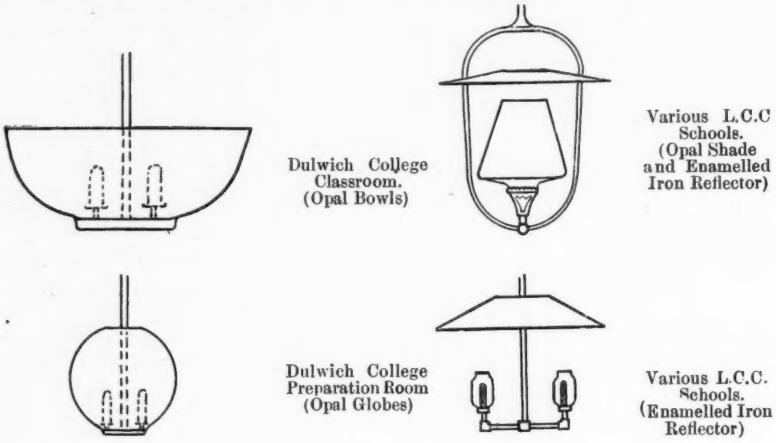
THE LIGHTING OF COLLEGES.

In the case of colleges the question of illumination assumes a somewhat different aspect. The lighting of lecture theatre, drawing offices, or laboratories, are quite distinct problems. It may be remarked, however, that, whereas in the case of elementary schools it is often necessary to practice rigid economy, this is less often the case for colleges. Engineering institutions in particular might be expected to do their lighting well, not only because the staff should presumably possess a technical interest in the subject, but also because they have frequently a lighting plant of their own which is more than sufficient to supply generous illumination to the entire building.

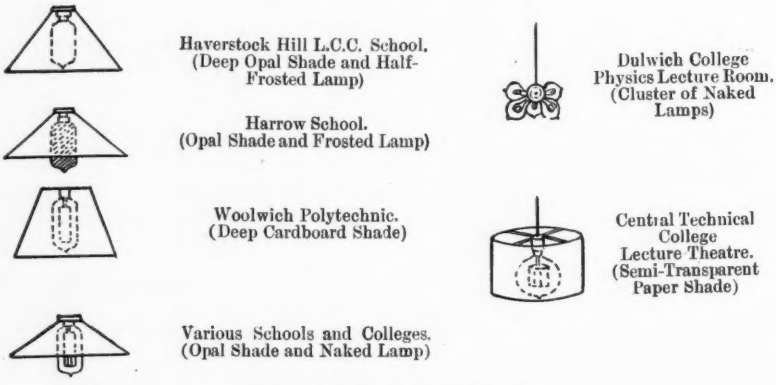
One would suppose that a lecture theatre, in the design of which special pains are often taken, would be regarded as furnishing an opportunity for special ingenuity in securing the most ideal lighting conditions, and that a pride would be taken in securing the most perfect arrangements. At present, however, it must be confessed that in most cases the lighting is often of a rule of thumb order, electric clear bulb lamps with opal shades, at regular intervals, forming the sole means of lighting. Even when frosted lamps are employed there is a risk of the lights interfering with the comfort of the audience unless their position is carefully determined.

Theoretically one would imagine that the chief essential in a lecture theatre is, as in classrooms, the provision of sufficient illumination on the desks, coupled with the avoidance of any glaring lights such as weary the eyes of students and make it difficult for the lecturer to see his audience. The latter condition was rarely satisfactorily complied with in the colleges visited. The next point to be considered would be the desirability of special lighting of the blackboard and diagram sheet, and of the lecture table where experiments are frequently arranged and which is the central point of interest. Here again it proved to be unusual for special provision to be made for this purpose, and such methods as are

used at present are clearly open to improvement. Indeed the illumination on the lecture table only rarely exceeds that on the desks, the reverse being often true. Some of the devices used to provide special illumination of this kind are shown in figure 8.


Dulwich College Classroom. (Opal Bowls)
Various L.C.C Schools. (Opal Shade and Enamelled Iron Reflector)
Dulwich College Preparation Room (Opal Globes)
Various L.C.C. Schools. (Enamelled Iron Reflector)

TYPES OF GAS FIXTURES.


Haverstock Hill L.C.C. School. (Deep Opal Shade and Half-Frosted Lamp)
Harrow School. (Opal Shade and Frosted Lamp)
Woolwich Polytechnic. (Deep Cardboard Shade)
Various Schools and Colleges. (Opal Shade and Naked Lamp)
Dulwich College Physics Lecture Room. (Cluster of Naked Lamps)
Central Technical College Lecture Theatre. (Semi-Transparent Paper Shade)

TYPES OF ELECTRIC FIXTURES.
FIG. 7.

In most cases, the light is very unevenly distributed (the problem being similar to the lighting of shelves in libraries), and the expenditure of energy devoted to this object appears excessive in comparison with that of the rest of the room.

An interesting method of lighting has been adopted in the electrical engineering lecture theatre of the Central Technical College. This is shown diagrammatically in Fig. 9, while Figs. 10 and 11 show actual views of the room. The general illumination is provided by tungsten lamps surrounded by paper screens and hung near the white ceiling; the effect is pleasant and subdued. Two screened enclosed arcs are used to furnish extra illumination for the demonstration table and diagrams. The illumination on the desks is 1–3 foot-candles, and on the lecture table 4·5 foot-candles.

In some institutions visited, *e.g.*,

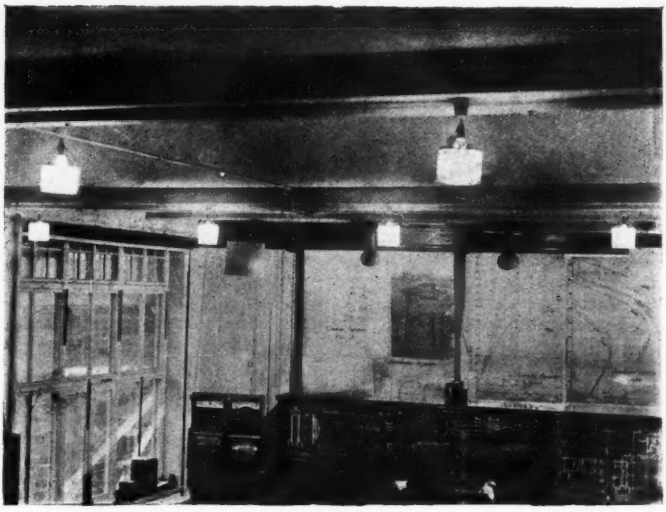


FIG. 10.—Central Technical College. Electrical Engineering Lecture Theatre, showing lighting of diagrams and blackboard by enclosed arcs.

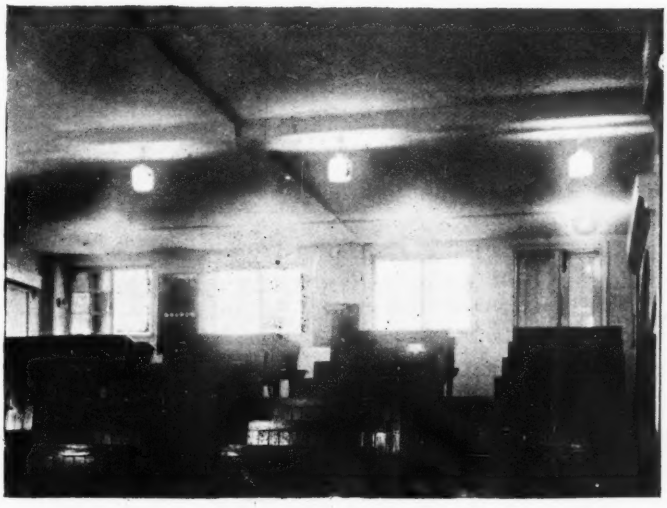


FIG. 11.—Central Technical College. Electrical Engineering Lecture Theatre, showing lighting of upper desks by screened tungsten lamps.

South Western Polytechnic, Westminster Technical Institute, &c., inverted arcs are utilized for the general lecture theatre lighting. The system, in conjunction with special local illumination for blackboard and demonstration table, has certain advantages as regards distribution of light, absence of glare, &c., and the very "flatness" of the impression, if it serves to accentuate the more brightly lighted parts of the room, may be a merit. It is however, essential in such cases to select well-designed lamps and good quality carbons; otherwise the flickering and spluttering of the lamps when turned on and off for lantern slides, &c., is apt to be an annoyance.

The general order of illumination in classrooms is about 2 foot-candles, although isolated instances in which some, or even the majority of the desks received only 0·5 foot-candles were met with.

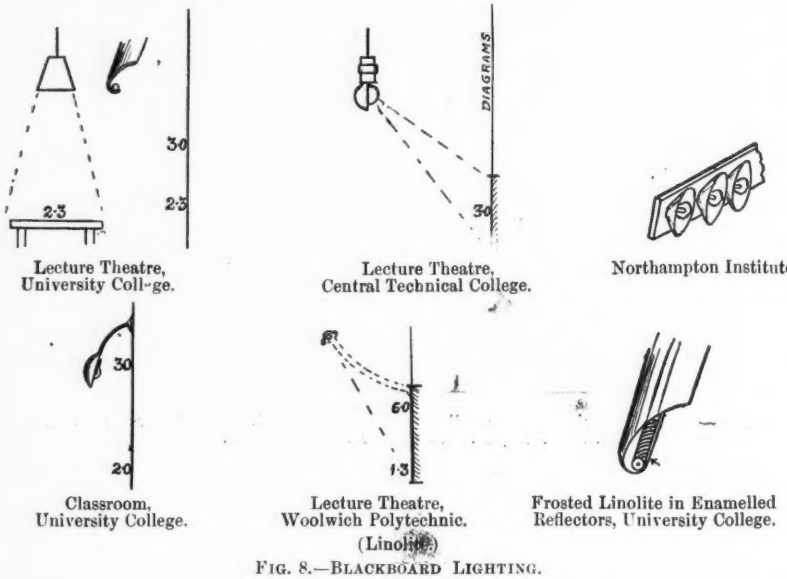


FIG. 8.—BLACKBOARD LIGHTING.

Indirect arc-lighting, and an intensity of illumination of 4 to 6 foot-candles is frequently used for drawing offices. When pendants are used it should hardly be necessary to point out the desirability of good shading. The arrangement shown in Fig. 13, as used at one London technical college, embodies a number of defects. The draughtsman can see the unscreened filament of the lamp at a distance of less than three feet away, and not only

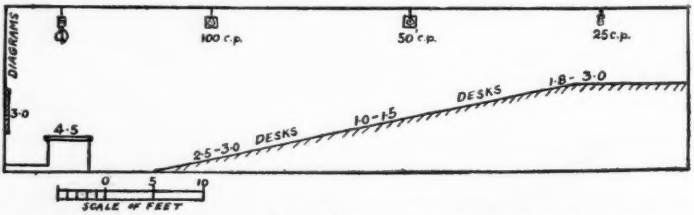


FIG. 9.—Lecture Theatre (Electrical Engineering) at Central Technical College.

this, but all the rows of lamps in front of him are visible. Possibly objection might also be taken to the direction from which the light comes, but it would take us too far afield to consider all the details of drawing-office lighting.

Finally, it may be pointed out that the effectiveness of experiments often depends on all the apparatus being clearly visible, and the use of special portable and well-screened lights for this purpose is to be encouraged.

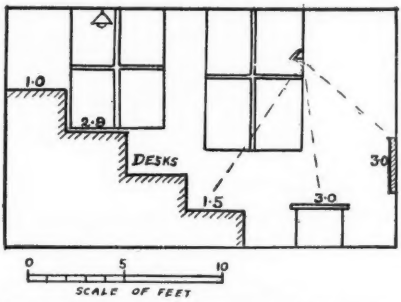


FIG. 12.—Lecture Theatre at the Birkbeck Institute, showing single row of lamps high up at back.

SOME CONCLUSIONS.

It is very interesting to observe that, just as in the case of libraries, the average illumination in schoolrooms seems to be in the neighbourhood of 2–3 foot-candles, and it may be suggested that this standard should be aimed at and preserved when ordinary class work is to be done. But when

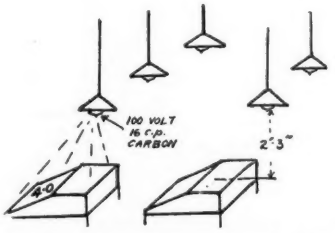


FIG. 13.—Unsatisfactory Arrangement of Lamps in Drawing Office.

extra fine work, sewing, &c., is carried out, a considerably higher value, say 5–10 foot-candles, seems to be required. A value of this order is commonly met with in drawing-offices, &c. As has been pointed out by Dr. Harman, the requirements of children and adults differ somewhat: it is particularly vital to supply good illumination for infants and growing children.

The second point that seems to require emphasis is the need for effective shading. There are still far too many cases in which undesirably bright sources of light are left unscreened and allowed to dazzle the eyes of students or children. No unscreened source should be allowed near the direct line of view.

The third point is the need for special local illumination of teacher's, or demonstration, table and the blackboard. At the same time it is admitted that the present methods of blackboard lighting could be improved by scientific study, and there seems a need for some form of fixture which will distribute the light quite evenly and screen the eyes of the audience while doing so.

DAYLIGHT ILLUMINATION.

Daylight, unlike artificial illumination, can be only very imperfectly controlled. The access of daylight is mainly determined by architectural considerations, and success or failure in this respect depends on the forethought of the architect. One may therefore lay stress on the need for consultation between the architect, the medical officer, and the lighting engineer *before* a school is built—a course which seems to be often followed on the Continent.

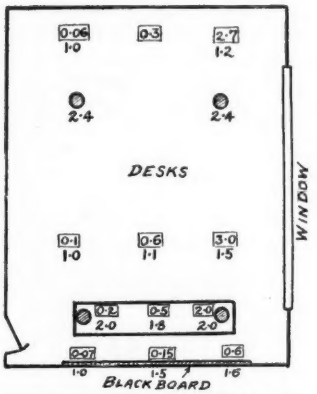
It will be recalled that in Fig. 1 the daylight and artificial illumination in a classroom at Haverstock Hill School were tabulated side by side. The most striking fact brought out is the large variation in the former from one side of the room to the other; to counteract this the two lights furthest from the window are controlled by a separate switch, so that they can be turned on to supplement the failing daylight illumination when needed.

The same variation is shown, even more strikingly, in the case of the Birkbeck Institute and a classroom at the Central Technical College, as shown in Fig. 14.

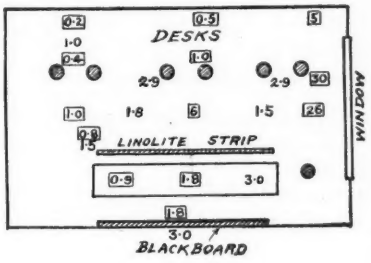
In the former case the illumination varies from 30 foot-candles down to

TABLE V.—ILLUMINATION DATA OF COLLEGES AND INSTITUTIONS.

College.	Nature of Lighting.	Consumption in Watts	Total Watts per sq. ft.	Illumination (foot-candles).		
				Demonstration Tables.	Desks.	Blackboard, &c.
CENTRAL TECHNICAL COLLEGE		estimated		measured		
Lecture Theatre (Elec. Engineering)	Tungsten	880				
	Tantalum	120	0·63	4·5	1·0-3·0	3·0
	Enclosed Arcs (2)	600				
Classroom No. 32	Carbon	720	1·1	1·8-2·0	1·0-2·4	1·0-1·6
UNIVERSITY COLLEGE						
Lecture Theatre (Elec. Engineering)	Tungsten	320				
	Tungsten (shaded), for demonstration table	150	2·0	2·3	3-3·5	2·3-3 Diagrams 3-7
	Linolite, for blackboard	600				
Classroom	Carbon	180	1·5	—	2·5-3·3	2-3·0
Laboratory	Carbon (for blackboard)	120				
	Tantalum (opal shades)	400	0·5	—	1·8	—
EAST LONDON COLLEGE						
Lecture Theatre (Elec. Engineering)	Tungsten (with Holophane Bowls)	1000	0·75	2·5	2·0-2·5	1·5-2·2
Drawing Office	Tungsten (with Holophane Reflectors)	1170	1·2	—	6·0	—
NORTHAMPTON INSTITUTE						
Classroom No. 72 (old)	Carbon	240	0·8	0·7	0·65	0·5
Lecture Theatre No. 73	Tungsten (opal shades)	150	0·6	2·0-2·5	1·5-2	1-1·5
	Carbon (for blackboard)	360				
Lecture Theatre No. 78 (New)	Tungsten (opal shades)	600	0·4	1·3-1·9	0·75-1·5	1·4
Drawing Office	Inverted Arcs	2000	1·15	3·8	3·7-5·3	2·8
BIRKBECK INSTITUTE						
Lecture Theatre (Physics)	Tungsten	210	0·75	3·0	1·0-2·9	3·0
	Linolite (for blackboard)	300				
Laboratory (Physics)	Tungsten (opal shades)	650	0·6	—	centre 3·5 side 1-2	—
SOUTH WESTERN POLYTECHNIC						
Lecture Theatre (Elec. Engineering)	4 Inverted Arcs (white ceiling)	1200	1·2	3·5	2-3·8	2·2
Lecture Theatre (Mech. Engineering)	4 Enclosed Arcs	1000	0·8	2·5	3-4	2
Drawing Office	Carbon (enamelled shades)	1800	2·0	4	4	0·5-1·0
WOOLWICH POLYTECHNIC						
Lecture Theatre	Linolite (screened)	810				
	Carbon	180	1·3	0·7-0·8	0·8-1·3	3·8-20
	Linolite (for blackboard)	540				
Classroom	Tungsten (cardb'd shades)	252	·94	2·4	2·8-4·4	0·8-2
	Linolite (for blackboard)	180				



Classroom (Central Technical College). Daylight Readings marked thus |1·5| taken at 4.45 P.M. Approximate Window Area per sq. ft. : 0·22.



Lecture Theatre (Birkbeck Institute). Daylight Readings marked thus |1·5| taken at 11 A.M. Approximate Window Area per sq. ft. : 0·13.

FIG. 14.—Difference in Distribution of Daylight and Artificial Illumination.

only 0·5. In the case of the classroom at the Central Technical College there is again a very wide variation, notwithstanding the fact that the room is a high one and one entire side is devoted to window space; one cannot help observing that even when the relation of window-space to floor area is not less than the prescribed value of one-fifth, there may often be some desks which receive insufficient illumination.

In both the cases referred to the view was blocked to some extent by buildings. A complete contrast is afforded by Harrow School. The window space in these old buildings appears at first sight clearly insufficient, the more so as they are composed of heavily latticed glass. We were informed, however, that the access of daylight was considered exceptionally good, the reason being that the school stands on a hill with no surrounding obstructions.

In passing, it may be mentioned that in all the schools and institutions visited it seemed to be accepted as an invariable rule that the windows should be on the left hand of the students. The only exception was one classroom at Harrow, where the antiquity of the building is probably the explanation. Seeing that this rule is so invariably followed in the case of daylight, one is led to ask why the same precept is not adopted in the case of artificial light, and whether a general illumination with light coming from all directions is equally effective?

The following approximate figures relating to the window space per square foot of floor area in different classrooms visited may be of interest :—

School or College.	Window area per sq. foot of floor (approx.)
CENTRAL TECHNICAL COLLEGE	
Class room	0·22
WOOLWICH POLYTECHNIC	
Class room	0·25
Lecture Theatre	0·17
BIRKBECK INSTITUTE	
Physics Lecture Theatre	0·13
HARROW SCHOOL	
Large Hall	0·16
Headmaster's class room	0·15
Mathematics „ „	0·15
ST. PAUL'S SCHOOL.	
Class room	0·16
CITY OF LONDON SCHOOL	
Class room	0·24

(Some interesting suggestions for a modification of the well-known rule, based on an abstract kindly supplied by Dr. Kerr, are added in the Appendix.)

In conclusion, it remains to make acknowledgment of the courtesy of the head masters and principals of colleges who gave permission for these tests to be made; special thanks are due to Mr. Fitzmaurice, the Chief Engineer, Mr. Chas. A. Baker, the Electrical Engineer, and Dr. J. Kerr, Medical (Education) Officer to the L.C.C., for granting facilities in this direction. The authors are also indebted to the kindness of Prof. T. Mather in granting permission for photographs of the electrical engineering lecture theatre at the Central Technical College, and to Mr. Mead, assistant at the College, by whom the photographs were prepared. It should be added that a number of the tests embodied in this paper were kindly carried out at the authors' request by Mr. A. Cunnington.

APPENDIX.

Note on the Dimensions of Windows in Schoolrooms.

(Engelbracht, Zentralblatt der Bauverwaltung, No. 52; Kleinere Mitteilungen in Zeitschrift für Schulgesundheitspflege, xxiv. i, Jan. 1911).

HITHERTO the rule has been followed that the window area in schoolrooms should be one-fifth of the floor area. This fraction of one-fifth, derived from practical experience, applies more especially to class-rooms in which the depth of the room from the window is about 6 metres.

When one considers that the intensity of the light derived diminishes with the square of the distance, it is evident that rooms of greater depth than the above tend to be underlighted, while those of smaller depth may receive an excessive amount of light.

Engelbracht has therefore developed a simple formula of useful application in such cases, namely $f = \frac{F}{5} \cdot \frac{t^2}{36}$,

where f = window area in square metres.
" F = floor " " " "
" t = depth of classroom in "

From this formula it follows that

with a depth of 7 metres,	$f = \frac{54}{5}$	$\cdot \frac{7^2}{36} = 14{\cdot}7$	sq. m., roughly	$\frac{1}{4}$ F.
" " " " 6 "	$f = \frac{54}{5}$	$\cdot \frac{6^2}{36} = 10{\cdot}8$	" " "	$\frac{1}{5}$ F.
" " " " 5 "	$f = \frac{54}{5}$	$\cdot \frac{5^2}{36} = 7{\cdot}5$	" " "	$\frac{1}{7}$ F.
" " " " 4 "	$f = \frac{54}{5}$	$\cdot \frac{4^2}{36} = 4{\cdot}8$	" " "	$\frac{1}{11}$ F.

It will therefore be seen that on this estimation classrooms having a depth of about 7 to 8 metres will in general be completely underlighted by the application of the rule referred to. On the other hand, in rooms of less than 6 metres depth needlessly large windows would be provided. According to researches undertaken in the Hanover district, Engelbracht's formula appears to have led to very consistently satisfactory results.

International Hygiene Exhibition in Dresden.

As previously announced, an International Exhibition dealing with hygiene is to be held in Dresden from May to October during this year, and among the matters dealt with it is proposed to include the subject of illumination and its bearing on health. The following letter has now been received from the British Executive Committee, inviting the co-operation of the Illuminating Engineering Society. Members who desire to exhibit apparatus or appliances connected with illuminating engineering are invited to communicate with the Hon. Secretary of the Illuminating Engineering Society.

INTERNATIONAL HYGIENE EXHIBITION,
DRESDEN, 1911.
British Executive Committee,
47, Victoria Street,
Westminster, S.W.
April 7th, 1911.

DEAR SIRS,—The British Committee decided at its meeting on April 3rd to proceed with the work of preparing a British Section at the forthcoming International Hygiene Exhibition at Dresden. A pavilion has been secured, and the authorities at Dresden have given the Committee permission to postpone the opening of the British Section until an early date in June.

I have been instructed by the Committee to take the necessary steps to secure really first-class scientific and popular material bearing on hygiene. Since the pavilion is smaller than was originally contemplated, and since the Committee has been handicapped by a number of unavoidable circumstances in undertaking this work at an earlier date, the Committee rely on the whole-hearted co-operation of those in charge of the various institutions, and of the private workers in hygiene, to enable it to put together a collection which will be worthy of Great Britain, and which will command the admiration of the visitors to the Exhibition. I am therefore writing to you to ask you to assist the Committee by (1) tending your valuable advice in regard to the nature of the exhibits illustrative of illumination; (2) considering where suitable exhibits are likely to be found; and (3) what material you yourself would be prepared to place at its disposal.

In order to avoid loss of time and unnecessary correspondence, I should be grateful if you will allow me to call on you at a time convenient to yourself for the purposes of discussing the *modus operandi*.

Trusting that you will be able to see your way to assist us in carrying out our work with expedition, and to a successful issue,

I am, dear Sir,
Yours faithfully,
H. W. ANNIT, Secretary.

Royal Sanitary Institute—Annual Congress.

As mentioned by the Chairman at the last meeting of the Illuminating Engineering Society, the Annual Congress of the Royal Sanitary Institute will take place on July 24th–29th. The following letter has been received, inviting the Illuminating Engineering Society to participate in this Congress, and members who would like to participate are requested to communicate with the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.).

The Royal Sanitary Institute,
90, Buckingham Palace Road, S.W.

26TH CONGRESS, BELFAST, JULY 24TH–29TH, 1911.

SIR,—The Royal Sanitary Institute have accepted an invitation from the City Council of the County Borough of Belfast to hold their 26th Congress and Exhibition in that City in July next.

The work of the Congress in the advancement of sanitary knowledge is closely related to the progress of important centres of population, and the various meetings afford an opportunity for the representatives of sanitary authorities to discuss the many problems arising in municipal and public health administration. The Exhibition held in connexion with the Congress enables them also to see and compare recent sanitary appliances, and to note those approved by a Committee of Experts.

The sanitary administration and practice of the centre in which the Congress is held, and the various municipal undertakings, are also brought under notice of those attending the meeting.

The Institute trust that your Council will appoint delegates to the Congress, and if you will forward to me on the enclosed form the names of the delegates so appointed, full information respecting the meeting will be sent to them.

The subscription for copy of *Proceedings* and ticket for the Congress is £1 1*s.* for each delegate appointed; this payment includes all the privileges of the Congress. Delegates will also be supplied with the proofs of the papers to be read, which will be issued as far as possible on the day preceding their reading. This arrangement has been found most advantageous in securing a practical and useful discussion.

I append a list of the authorities who have previously appointed delegates.

I am, Sir,
Yours faithfully,
(Signed) W. WHITE WALLIS, Secretary.

Combined Gas and Electric Street Lighting Suggested for Holborn.

READERS will recall the negotiations which have been proceeding in Holborn where the Borough Council have had before them, during the past year, competing tenders from the gas and electrical supply companies; the varying fortunes of the competing parties have been watched with considerable interest, but both now appear to have found the conditions irksome; the ultimate result has been an effort of co-operation between the competing companies, which forms a most striking precedent.

The situation is explained by the following joint letter from the Gas Light and Coke Co. and the Electric Supply Companies. A common specification has been drafted and a scheme proposed for lighting the Borough partly by gas and partly by electricity:

The Gas Light and Coke Company,
Horseferry Road,
Westminster, S.W.
11th April, 1911.

DEAR SIR,—The decision of your Council that the Gas and Electric Companies should be requested again to submit tenders for the public lighting of the Borough has received our careful consideration, and we have found it necessary to confer together on the subject, not only because the details of our previous tenders have been made public, but because of the onerous character of certain of the clauses of the new specification which accompanied your present invitation. The result of this conference is that we are unable, under the circumstances, again to quote in competition with each other, but we venture to submit instead a scheme for lighting the Borough partly by gas and partly by electricity for an inclusive annual payment of £6,950, a sum less than the amount of the tender recommended for acceptance by your Works Committee in February last.

We enclose herewith a schedule and map showing how we should suggest to apportion the lighting. We have, in the scheme submitted, followed very closely your Surveyor's specification, but have ventured to suggest some modifications, which we hope will be regarded as improvements, at certain points, principally in Holborn, New Oxford Street, and Shaftesbury Avenue, with a view to making your lighting comparable with the high standard recently set in neighbouring boroughs.

Our tender is based on a ten years' contract, and in the schedule hereto are set out the sums payable by the Council if the contract is terminated at shorter periods.

With regard to clause 28 of the specification, although we undertake to maintain our lamps in the highest degree of efficiency, we are unable to submit to so heavy a penalty as you ask, and maintain the price above quoted. If, therefore, this penalty is to be insisted on, we should require an increase of 10 per cent on the price.

With regard to Clause 35, we are unable to agree to adopt improved burners, lamps, or appliances unless the Council agree to pay the extra cost entailed by such improvements.

In conclusion, we trust that this offer will prove acceptable to your Council. For an expenditure but slightly in excess of what they are at present paying, the present candle-power in their streets will be increased by 170 per cent, with the additional advantage of providing the Borough with the best and latest improvements obtainable from both forms of illuminant,

We are, dear Sir,
Yours faithfully,
(Signed) E. CUNLIFFE OWEN,
Secretary, Metropolitan Electric Supply Co., Ltd. (acting in conjunction with the Charing Cross, West End and City Electricity Supply Co., Ltd., and the County of London Electric Supply Co., Ltd.)
(Signed) H. RAYNER,
Secretary, The Gas Light and Coke Company.

The tender has now been referred to the Works Committee for report. From the standpoint of this journal the interesting point is the unique illustration presented of the advantages of concerted effort between representatives of gas and electric lighting. We may perhaps be allowed to quote the concluding paragraph referring to the matter in *The Electrical Times*:—

"The best thing about the whole affair is perhaps that a spirit of tolerance has made its appearance in the doings of the gas and electric lighting companies. This coalition must be the first visible sign of the millennium."

But it is a sign which became visible to readers of this journal quite a long time ago.

Notes on Standard Specifications for Street-Lighting.

(A Guide to Recent Literature on this Subject.)

It will be recalled that, at a meeting of the Illuminating Engineering Society on December 9th, 1910, the President mentioned that the Council had appointed a Committee to consider the framing of a draft Specification on Street Lighting—an announcement which excited the keenest interest.

Since that time the matter has been the subject of a considerable amount of comment in the technical press. It may therefore be of interest to review some of the suggestions in this direction that have been made, and to recall a few of the contributions that have appeared from time to time bearing on the subject.

What is meant by a well-lighted Street?

It is clear that in drafting a specification of this kind one requires a fairly definite conception as to what constitutes the ideal illumination of a street. On this point much still remains to be decided. It has been pointed out that the requirements of various classes of streets are quite distinct: what suffices for a side street may not answer for a main thoroughfare. Again, even among important streets, one must treat a road along which heavy traffic is constantly passing in a different manner from one which is used mainly by pedestrians; the best method of lighting also probably depends on the width of the street, the height and nature of the buildings lining it, the number of shops, and other local characteristics.

One point that has led to some discussion is the desirability or otherwise of directing nearly all the light downwards on the roadway and pavement. It has been argued that the main function of street lamps is to light up pavement and road, and special reflectors have therefore been designed with a view to focussing the light in this way.[2] It has been often suggested that what is needed is *uniform illumination*, every part of the street being as well illuminated as any other; but it is also suggested that at important corners and crossings, where the traffic is notoriously complicated, some additional light should be provided. On the other hand, it is also argued that the general appearance of the thoroughfare often demands a considerable amount of light being allowed to fall on the buildings—even though the majority of this illumination may be absorbed by their comparatively dark reflecting surfaces. But it is apparently now generally recognized that at least *most* of the light should be directed downwards, and sources of light are therefore preferred which have a form of distribution curve desirable from this standpoint. A distinction has also to be drawn between main thoroughfares which it is desired, strictly speaking, to "illuminate" and side streets, in which it is frankly recognized that the same order of illumination cannot be afforded; in these cases, the lamps are arranged rather with a view to "beacon-lighting," that is, marking out the boundary between pavement and roadway.

In selecting a method of street lighting such questions as the effect of "glare" on the part of the actual sources, the spacing of lamps, and their arrangement in the street, &c., are also important. For example, in 1908 Mr. C. A. Baker, had already recommended the method of hanging lamps centrally along the street, stating that a saving of 30 per cent in energy for the same illumination had been secured by this means in Milan,[3] and the relative merits of side and central suspension have recently

[1] *Illum. Eng.*, Lond., Jan., 1911, p. 27.

[2] *E.g.*, Equilux and Hrabowski reflectors (*Illum. Eng.*, Lond., vol. iii., 1910, p. 443.)

[3] *Illum. Eng.*, Lond., vol. i., 1908, p. 783.

been much discussed, notably at a meeting of the Illuminating Engineering Society last December.

The question has also been debated whether it is better to rely upon a few powerful units at a considerable distance apart, or small lamps placed nearer together. Mr. Haydn T. Harrison has given reasons for preferring the latter plan, and Mr. A. J. Sweet has shown that theoretically it would be desirable, both with a view to avoiding glare and also in order to secure good uniformity of illumination, that the ratio between the distance apart of two lamps and their height of suspension should not exceed 4 : 1.[4] In any case, it is pointed out, the occasions on which a system of street illumination can be designed *de novo* are few and far between; as Dr. Bell put it in his presidential address before the Illuminating Engineering Society (U.S.A.) in 1908: "Street lighting....has proceeded to a certain extent along the lines of least resistance. Lamps were put, not in the best places for them, but where they could be put in with the least disturbance to individuals."

The question must therefore be considered, How far in framing a standard specification for street lighting can it be assumed that positions of lamps are capable of being changed or new arrangements adopted; this depends largely on local circumstances, and therefore it may be suggested that any specification which will meet with general acceptance should allow considerable latitude in this respect.

General Nature of Street-Lighting Contracts.

The earliest forms of street lighting contracts in this country involved the provision of a certain number of oil-lamps, set outside the houses at prescribed distances along the street. It is to be noted that this was originally the duty of individual householders, and that it was only on moonless nights that hanging out a lantern was obligatory. Subsequently the duty was undertaken by the City authorities.

When eventually oil lamps were replaced by gas and electricity, the method of prescribing the use of certain forms of lamps was still adhered to; but when the measurement of the amount of gas or electricity came to be regarded as a well understood and feasible process, the amount to be consumed by each lamp was also stated in contracts.

So long as the choice of lamps and the possible methods of arranging them were limited, adherence to a certain gas or energy consumption was regarded as a fair security to the ratepayers that the lighting was up to the standard. But, when the measurement of light and illumination came to be better understood, the idea gained ground that the essential thing was the provision of a certain illumination in the street, and that the contracts ought, therefore, to be drawn up in such a way as to encourage the use of such forms of lamps and appliances as were most efficient in transforming gas or electricity into light.

In this country much interest was aroused by the form of specification adopted by the Westminster City Council in 1909, and described in a paper before the Institution of Gas Engineers by Mr. J. Abady in that year.[5]

In this paper, to which further reference will be made shortly, the three chief forms of contract are based on (1) energy supply; (2) energy supply *plus* maintenance; and (3) supply of light irrespective of energy. For the moment we need only note the interesting precedent set by the fact that actual periodical measurements of the candle-power of the lamps were specified, and formed an integral part of the contract.

Some authorities have been so much impressed by the fact that the ultimate object of street lamps is to provide a certain illumination that they have advocated "selling illumination," irrespective of the means by which it is secured. The general opinion, however, seems to be that, however desirable theoretically, the time is not yet ripe for such a step. Louis Bell has recently expressed the view that while measurements of illumination in a street are a very serviceable weapon of research

[4] *Illum. Eng.*, Lond., vol. iii., 1910, p. 654.

[5] *Illum. Eng.*, Lond., vol. iii, 1910, p. 434.

and comparison, it would not be desirable at the present time to base a contract entirely on the tests of this description.[6]

Summed up, this view asserts that, at present, a street lighting contract should not be based *solely* on the provision of a certain amount of illumination. In this connexion a remark in a recent editorial in this journal may be quoted that "It would be a preferable method to base the contract on a suitable combination of two systems, namely, to specify the provision of a certain minimum illumination, and, in addition, a minimum energy supply."

The actual gas or electricity consumed can probably be measured and checked with sufficient exactitude, but the exact measurement of the light given by street lamps, whether in the form of candle-power or actual illumination on the road or pavement, is at present a less certain process. The questions may therefore be raised at this stage whether it is desirable, in specifying candle-power and illumination, to impose a penalty in the event of apparent failure to reach the required standard, and, if so, what latitude as regards change in the light should be permissible?

Measuring the Candle-power of Lamps supplied.

One point, however, seems to receive very general approbation, namely, the desirability of including *some* form of check on the amount of light supplied. To a certain extent this can be done by specifying the type of lamp and the amount of gas or electricity it consumes. But there is a growing conviction that in cases in which a large area has to be lighted, and considerable sums of money will be spent, preliminary tests of the light yielded by the competing lamps are needed. Bell, for example (*loc. cit*), strongly advocates that, whatever periodical measurements in the streets may be made, it is also necessary to carry out careful and exact tests on the competing sources in the laboratory before the contract is awarded, and this course was followed when the street lighting of Boston was under consideration.[7]

In this connexion it is necessary to consider the basis on which the illuminating value of different sources should be compared. Fortunately, there is agreement between Great Britain, France, and the United States on the unit to be employed, which is identical with the "candle" derived from the Harcourt 10 c.-p. lamp. But there is still lack of agreement as to how candle-power should be specified in these tests, *i.e.*, whether mean spherical, mean hemispherical, or mean candle-power in any specified direction. Prof. Strache has recently pointed out the difficulty of comparing the performances of gas lamps in Germany and in this country on account of the different methods of specifying candle-power adopted.[8] Clearly it is not desirable to state the candle-power in one direction only, and it has sometimes been recommended that the mean spherical c.-p., which is a measure of the total amount of light sent out in all directions, should therefore be specified. In the case of street-lighting, however, so much importance is attached to the amount of light thrown downwards that it has been suggested that the mean lower hemispherical c.-p. should invariably be stated. This is very generally done in Germany, but in this country values are still often stated in terms of the light yielded at some particular angle.

Some, however, do not regard even mean hemispherical candle-power as a true measure of the illuminating power of a source in streets.[9] They point out that, in order to secure uniform illumination in the streets, the light given out at certain inclinations should be specially powerful; hence it might happen that two lamps had the same mean hemispherical c.-p. and yet one was much better fitted to light a street than another. In other words, the polar curve of light distribution must also be considered in selecting a lamp besides

[6] *Trans.* Amer. I.E.S., May, 1910.

[7] See *Illum. Eng.*, Lond., vol. ii., 1909, pp. 402, 481, 529.

[8] *Illum. Eng.*, Lond., vol. ii., 1909, p. 489.

[9] W. H. Y. Webber, *Gas World*, March 21, 1908.

been much discussed, notably at a meeting of the Illuminating Engineering Society last December.

The question has also been debated whether it is better to rely upon a few powerful units at a considerable distance apart, or small lamps placed nearer together. Mr. Haydn T. Harrison has given reasons for preferring the latter plan, and Mr. A. J. Sweet has shown that theoretically it would be desirable, both with a view to avoiding glare and also in order to secure good uniformity of illumination, that the ratio between the distance apart of two lamps and their height of suspension should not exceed 4 : 1.[4] In any case, it is pointed out, the occasions on which a system of street illumination can be designed *de novo* are few and far between; as Dr. Bell put it in his presidential address before the Illuminating Engineering Society (U.S.A.) in 1908: "Street lighting....has proceeded to a certain extent along the lines of least resistance. Lamps were put, not in the best places for them, but where they could be put in with the least disturbance to individuals."

The question must therefore be considered, How far in framing a standard specification for street lighting can it be assumed that positions of lamps are capable of being changed or new arrangements adopted; this depends largely on local circumstances, and therefore it may be suggested that any specification which will meet with general acceptance should allow considerable latitude in this respect.

General Nature of Street-Lighting Contracts.

The earliest forms of street lighting contracts in this country involved the provision of a certain number of oil-lamps, set outside the houses at prescribed distances along the street. It is to be noted that this was originally the duty of individual householders, and that it was only on moonless nights that hanging out a lantern was obligatory. Subsequently the duty was undertaken by the City authorities.

When eventually oil lamps were replaced by gas and electricity, the method of prescribing the use of certain forms of lamps was still adhered to; but when the measurement of the amount of gas or electricity came to be regarded as a well understood and feasible process, the amount to be consumed by each lamp was also stated in contracts.

So long as the choice of lamps and the possible methods of arranging them were limited, adherence to a certain gas or energy consumption was regarded as a fair security to the ratepayers that the lighting was up to the standard. But, when the measurement of light and illumination came to be better understood, the idea gained ground that the essential thing was the provision of a certain illumination in the street, and that the contracts ought, therefore, to be drawn up in such a way as to encourage the use of such forms of lamps and appliances as were most efficient in transforming gas or electricity into light.

In this country much interest was aroused by the form of specification adopted by the Westminster City Council in 1909, and described in a paper before the Institution of Gas Engineers by Mr. J. Abady in that year.[5]

In this paper, to which further reference will be made shortly, the three chief forms of contract are based on (1) energy supply; (2) energy supply *plus* maintenance; and (3) supply of light irrespective of energy. For the moment we need only note the interesting precedent set by the fact that actual periodical measurements of the candle-power of the lamps were specified, and formed an integral part of the contract.

Some authorities have been so much impressed by the fact that the ultimate object of street lamps is to provide a certain illumination that they have advocated "selling illumination," irrespective of the means by which it is secured. The general opinion, however, seems to be that, however desirable theoretically, the time is not yet ripe for such a step. Louis Bell has recently expressed the view that while measurements of illumination in a street are a very serviceable weapon of research

[4] *Illum. Eng.*, Lond., vol. iii., 1910, p. 654.

[5] *Illum. Eng.*, Lond., vol. iii, 1910, p. 434.

and comparison, it would not be desirable at the present time to base a contract entirely on the tests of this description.[6]

Summed up, this view asserts that, at present, a street lighting contract should not be based *solely* on the provision of a certain amount of illumination. In this connexion a remark in a recent editorial in this journal may be quoted that "It would be a preferable method to base the contract on a suitable combination of two systems, namely, to specify the provision of a certain minimum illumination, and, in addition, a minimum energy supply."

The actual gas or electricity consumed can probably be measured and checked with sufficient exactitude, but the exact measurement of the light given by street lamps, whether in the form of candle-power or actual illumination on the road or pavement, is at present a less certain process. The questions may therefore be raised at this stage whether it is desirable, in specifying candle-power and illumination, to impose a penalty in the event of apparent failure to reach the required standard, and, if so, what latitude as regards change in the light should be permissible?

Measuring the Candle-power of Lamps supplied.

One point, however, seems to receive very general approbation, namely, the desirability of including *some* form of check on the amount of light supplied. To a certain extent this can be done by specifying the type of lamp and the amount of gas or electricity it consumes. But there is a growing conviction that in cases in which a large area has to be lighted, and considerable sums of money will be spent, preliminary tests of the light yielded by the competing lamps are needed. Bell, for example (*loc. cit*), strongly advocates that, whatever periodical measurements in the streets may be made, it is also necessary to carry out careful and exact tests on the competing sources in the laboratory before the contract is awarded, and this course was followed when the street lighting of Boston was under consideration.[7]

In this connexion it is necessary to consider the basis on which the illuminating value of different sources should be compared. Fortunately, there is agreement between Great Britain, France, and the United States on the unit to be employed, which is identical with the "candle" derived from the Harcourt 10 c.-p. lamp. But there is still lack of agreement as to how candle-power should be specified in these tests, *i.e.*, whether mean spherical, mean hemispherical, or mean candle-power in any specified direction. Prof. Strache has recently pointed out the difficulty of comparing the performances of gas lamps in Germany and in this country on account of the different methods of specifying candle-power adopted.[8] Clearly it is not desirable to state the candle-power in one direction only, and it has sometimes been recommended that the mean spherical c.-p., which is a measure of the total amount of light sent out in all directions, should therefore be specified. In the case of street-lighting, however, so much importance is attached to the amount of light thrown downwards that it has been suggested that the mean lower hemispherical c.-p. should invariably be stated. This is very generally done in Germany, but in this country values are still often stated in terms of the light yielded at some particular angle.

Some, however, do not regard even mean hemispherical candle-power as a true measure of the illuminating power of a source in streets.[9] They point out that, in order to secure uniform illumination in the streets, the light given out at certain inclinations should be specially powerful; hence it might happen that two lamps had the same mean hemispherical c.-p. and yet one was much better fitted to light a street than another. In other words, the polar curve of light distribution must also be considered in selecting a lamp besides

[6] *Trans.* Amer. I.E.S., May, 1910.

[7] See *Illum. Eng.*, Lond., vol. ii., 1909, pp. 402, 481, 529.

[8] *Illum. Eng.*, Lond., vol. ii., 1909, p. 489.

[9] W. H. Y. Webber, *Gas World*, March 21, 1908.

its mean intensity in the lower hemisphere. Yet here again, stress has been laid on the fact that the kind of polar curve suited for some streets might not answer for others; it has also been remarked that the desirable polar curve depends on the distance between the lamps. Some remarks on this and other aspects of street-lighting tests were recently contributed to the *Journal of Gaslighting* by R. Watson, of Doncaster (Feb. 28). It is possible that this difficulty will be mitigated in the near future by the more general use of special globes or reflectors intended to modify the natural polar curve of light distribution, and secure exactly that which the local circumstances demand. But in any case it would seem that in drawing up a specification one can hardly hope to find a simple formula which will *both* be applicable to a wide variety of local conditions, and completely define the qualities of a lamp from the standpoint of street-lighting; one should therefore be prepared to accept tentatively a method which, in spite of admitted limitations, forms the best compromise possible in the circumstances.

Quite apart from this question of expressing candle-power, there is the additional problem: How it is to be measured. Are we, as Bell has suggested, to rely mainly on exact tests in the laboratory, or to endeavour to measure the candle-power of the lamps used in their actual position in the streets?

One of the most recent examples of specifications embodying this suggestion is that recently adopted by the Westminster City Council. It seems to have been desired to obtain the candle-power of the lamps used in mean hemispherical c.-p.; but tedious and elaborate methods would have been demanded to obtain this candle-power with exactitude in the streets, and accordingly it was specified that the mean of the candle-power at two angles only, namely, 20° and 50° to the vertical, should be tested. J. Abady, in describing this method, contends that the mean value so obtained is practically equivalent to mean lower hemispherical c.-p. in the case of all ordinary sources. This, however, has been questioned by K. Edgcumbe[10] and it has been suggested that a maker might purposely accentuate the candle-power at these two angles, so as to bring the candle-power of his lamp up to specification, and meantime allow the intensity in other directions to be abnormally low. In this connexion Abady remarks: "Of course, it might be possible for an enterprizing individual to make a lamp giving 180 candles at 50 and none elsewhere, and this would be (according to the above method of testing) a 90 c.-p. lamp; but a lamp such as this would not comply with the general specification of the Westminster testing clause."

There is also the further question whether, if one lamp happens to fall below the permissible 10 per cent drop in candle-power this in itself will involve a penalty. The contract described by Abady meets this point by suggesting that if one lamp falls below the standard, tests shall also be made of the two adjacent ones. If the aggregate of the light from the three lamps equals the aggregate required by the contract, no damages shall be recoverable. We see here an apparent approach to the form of contract based on illumination, in which the actual street illumination, irrespective of how it is derived, is to be kept up to the specified value.

The objection raised by L. Bell to all forms of measurement in the street, as a basis of contract, is founded mainly on the fact that many street lamps fluctuate considerably in candle-power; apart from this, it is difficult to secure in street photometry an approach to the accuracy attainable in the laboratory.

The advocates of methods of measuring illumination, on the other hand, point out that in measuring the candle-power of individual sources in the street special precautions are needed to avoid stray light, and that, in some positions, it is hardly possible to prevent the reading being affected by other adjacent lamps besides the one tested.

[10] *Electrician*, July 15, 1910.

Specifications based on Illumination.

A somewhat different standpoint from the above has been taken by those who advocate specifications based on the measurement of illumination. It is urged that what really concerns us is not so much the energy consumed by the lamps, not even the candle-power of these lamps, but *the actual distribution of illumination over the pavement and roadway*. This illumination is quite distinct from candle-power, and can be expressed irrespective of how it is obtained. The method therefore is said to lend itself very readily to the comparison of the results obtained by different systems of street illumination.

In Great Britain the foot-candle is the unit almost exclusively used, but on the Continent the lux or metre-candle is used. Monasch, who has given a convenient table connecting the various units of illumination employed,[11] points out that some little uncertainty is attached to the latter term. In Germany the lux is often used to mean metre-candle, Hefner units being understood; in France metre-candle in terms of the so-called "international candle."

On closer examination one finds that some of the specifications purporting to be based on illumination are really equivalent to measuring candle-power. For example, in the specification drafted by the National Electric Lamp Association, mentioned by Haydn Harrison,[12] it is stated:—

"With lamps spaced 200 to 600 feet apart the specification should define the mean illumination thrown by the individual lamp in position in the street, as measured at the height of the observer's eye, *and perpendicular to the rays*, at some point not less than 200 or 300 feet distant from a position immediately below the lamp."

If illumination is measured in a plane perpendicular to a particular ray, this is practically equivalent to measuring the candle-power of the lamp in that direction, and Harrison has calculated the c.-p. of street lamps by this means.[13] On the other hand, measurements of illumination in a horizontal plane have been very extensively made; such a plane is open to receive light from a number of lamps, and even by reflection from adjacent buildings; it is contended that a test of this kind approaches much nearer to the thing we really desire to know, namely, the actual illumination on the pavement or roadway, that it takes into account and gives the system the benefit of any reflection off walls and buildings, &c., there may be, and that it gives a mean result which will be less affected by any particular lamp being below par. As mentioned previously, it is also claimed to present a better means of comparing the results obtained from different systems of lighting than by any other method.

On the other hand, it has been urged by those who prefer to measure candle-power that, for these very reasons, a measurement of illumination is too indefinite—that there are too many factors which may vary from time to time and affect the result. For example, if the surfaces of buildings in one street are lighter than in another, and if the street is narrower, the illumination may be affected thereby.

Measurement of Illumination in Vertical, Horizontal, or Inclined Planes.

Although, as stated above, the favourite method of measuring illumination is to do so in a horizontal plane, some have preferred to measure the illumination always in a plane perpendicular to the ray from the lamp; but in this case it is not possible to receive light from all available sources on the photometer screen. L. Bell and A. J. Sweet, who consider the horizontal method the best, state that the fact that the reading in the normal plane is naturally higher has sometimes been an inducement.

Some have been struck by the importance of vertical illumination, pointing out that besides the illumination of the horizontal footway we also desire to be able to see the face of an acquaintance, the faces of moving vehicles, &c. For experimental purposes, curves

[11] *Illum. Eng.*, Lond., vol. ii., 1909, p. 742.
[12] *Illum. Eng.*, Lond., vol. i., 1908, p. 34.
[13] *Illum. Eng.*, Lond., vol. i., 1908, p. 470.

of vertical illumination in vertical planes have often been taken, for example by Drehschmidt.[14] However, it has also been observed that while such measurements may be serviceable from the experimental standpoint, they are hardly suitable for a specification, on account of the uncertainty as to which vertical plane should be selected. In any case light from some available sources might not strike a vertical screen, and the great advantage of the horizontal screen, is — it is free to receive light from all quarters, is missed.

The objections formerly urged against the method of measuring horizontal illumination seem to be based on some photometric difficulties encountered. It is true that the convenience and accuracy of such measurements have been much improved of late years, and that detailed tests have been made by Bloch,[15] Drehschmidt,[16] Trotter,[17] Voysey,[18] and many others. But it is pointed out that although results which are of admitted value for experimental purposes have been and can be obtained, some care is necessary in order to make the method the basis of a standard specification.

A discussion on these points, in which Trotter, L. Wild, Harrison, R. Smith, and others participated, took place in the columns of the *Electrical Review* (London), in 1908.[19] Attention was drawn to the exceedingly low illumination (sometimes as low as $\frac{1}{100}$ of a foot-candle), which may be encountered when a horizontal screen is used. This alone naturally serves to make photometric measurements difficult, both because it is hard for the eye to judge at such weak illuminations, and also because few available instruments are adapted for such a low range. Another possible source of error at these abnormally low illuminations is the Purkinje effect, which might lead to inconsistent results when lights of different colours are compared. For example, P. S. Millar has recorded that inconsistent results were obtained when measuring the illumination from a titanium arc lamp in the streets; at the more remote distances the apparent candle-power was 30 per cent above what it should have been.[20] On the other hand, it appears that such very weak illuminations are mainly characteristic of side streets, to which, presumably, the specification would not be applied: provided one dealt with main streets in which the illumination could be kept above 0·1 foot-candle, the difficulty would be removed.

Another possible difficulty arises from the fact that the rays from some street lamps strike the photometer surface very obliquely indeed; consequently it is suggested that a small tilt of the horizontal surface might, in such cases, lead to error.

Again it has been pointed out, especially by advocates of the candle-power system of measurement, that what is measured in such cases as the above is, strictly speaking, not the illumination but the "surface brightness" of the photometer screen. Now so long as such a screen is presented normally to the light rays the two things are practically synonymous. But probably no surface, however carefully prepared, obeys the cosine law *exactly* when the light rays strike it very obliquely; consequently an error due to this effect *may* come in when any large proportion of the incident light comes at these very oblique angles. Recently efforts have been made to secure screens which are as matt as possible. For example, it is stated that in the case of the ground celluloid screen used with the Holophane Lumeter, practical agreement with the cosine law is secured up to an angle of incidence of 80 degrees. Again, in a series of tests recently made in the streets of Budapest, a special standard screen consisting of a plaster of paris base treated with fine magnesia was used with the same object.[21]

[14] *Illum. Eng.*, Lond., vol. i., 1908, p. 951.
[15] *Illum Eng.*, Lond., vol. i., 1908, p. 953.
[16] *Loc. cit.*
[17] *Illum Eng.*, Lond., vol. iii., 1910, p. 479.
[18] *Illum. Eng.*, Lond., vol. i., 1908, p. 561.
[19] *Elec. Rev.*, Lond., Dec. 20, 27, 1907; Jan. 17, 24, 31; Feb. 14, 21, 1908.
[20] *Illum. Eng.*, Lond., vol. iii, 1910, p. 30.
[21] Jehl, *Elec. World*, April 28, 1910, pp. 1062-1064.

The above are a few of the objections brought against horizontal measurements. Probably before judging how far they deserve consideration more exact and complete practical experiments *ad hoc* are needed, but it seems reasonable to suppose that recent improvements rendered them much less considerable. It must also be remembered that many such errors would be of small consequence were a reasonable latitude in judging the illumination allowed. A complete series of tests in the streets, carried out simultaneously by various observers, and with a number of different instruments, would no doubt yield some useful information.

However, the practical convenience of the horizontal illumination measurement, and its value as a means of portraying actual conditions, are regarded as substantial advantages: this is possibly the most widely used of all methods of examining the conditions of illumination in streets, and it has thus the additional merit of being a familiar process to many investigators. Another advantage is that measurements of illumination in interiors, outside yards, &c., are usually made in a horizontal plane, and it is naturally a convenience to use the same method and instrument in all cases.

One matter remains to be mentioned, namely, the height of the horizontal plane above the ground. It is inconvenient to make measurements on the actual pavement, and, as Trotter has pointed out, very little difference is usually made by raising the height a few feet. In this country and in the United States various observers have used 3 feet, 3 ft. 6 in. and 4 feet, for the heights of their planes, in this respect agreeing fairly closely with the Continental standard (recently officially adopted by the Verband Deutscher Elektrotechniker) of one metre.

Measurement of Mean, Maximum, and Minimum Illumination.

Assuming, however, that measurements are made in a horizontal plane, the question remains, in what positions are measurements essential? It has been suggested that in street lighting we are mainly interested in two things (1) the value of the illumination and (2) the degree of uniformity. In order to study these points completely, it would be necessary to map out the illumination at intervals along the pavement and to observe the maximum, minimun, and mean illumination. The mean illumination is thus a measure of the intensity of the light provided and the ratio maximum: minimum is a measure of the degree of uniformity attained. The latter quantity is commonly studied by observers interested in the subject. Thus Harrison[22] has given the extreme variation in the illumination in certain streets in Marylebone as only 6 : 1 and Sweet has shown that it is possible to secure complete uniformity provided that the ratio of distance between lamps to height of post does not exceed 4 : 1.

It has therefore been suggested that a complete specification should require all the above quantities to be stated, special stress being laid on the provision of a certain minimum illumination. J. Sumec[23] has further suggested that the product of mean and minimum illumination would be useful, and might be taken to include *both* the desired qualities of sufficiency and proper uniformity of illumination.

If all that is required is an initial test on these lines once and for all, the labour involved is not unreasonable.

But it would probably be considered too laborious to make periodical tests of the street illumination in this way. It has been suggested that, after the initial exploration, a satisfactory method of judging whether the illumination was up to the mark would be a periodical test of the minimum illumination. In this case all that would be necessary would be to set the photometer at the agreed point and to pass quickly along the street, merely assuring the balance never moved below this set value. A matter which must be considered in this connexion is how far a purely temporary failure to reach the minimum, owing to a sudden fluctuation in the lamp

[22] Paper read before the Inst. of Elec. Engineers, Nov. 24, 1910: *Illum. Eng.*, Lond., Jan., 1911, p. 14.

[23] *Elek. u. Masch.*, Jan., 1910.

or the breakage of a mantle, &c., would be held to demand a penalty.

The Specification of the Verband Deutscher Elektrotechniker.

Special interest attaches to the standard conditions for testing illumination agreed upon by the Verband Deutscher Elektrotechniker in Germany last year. These conditions are applicable both to outdoor and indoor measurements. They have been submitted to the Verein von Gas-und Wasserfachmännern for approval, but no announcement as to whether the suggested method is acceptable to both bodies has yet been made. The decision of chief interest for the present purpose was that illumination should be measured in a horizontal plane one metre above the ground; it was further decided that the mean maximum and minimum illumination should be stated. Further recommendations are that specific consumption should be stated in terms of the amount of electricity or gas consumed (watts in the case of electric lamps and litres of gas per hour for gas lamps) in order to produce a mean illumination of one lux over an illuminated area of one square metre. (*Illum. Eng.*, Lond., vol. iii., 1910, p. 403.)

Intensity of Illumination Demanded.

Assuming that horizontal illumination is specified, and that only a specification for important main streets is contemplated, the question remains what order of illumination is to be expected.

We have referred to Haydn Harrison's figures for Oxford Street, and the same authority in an article in the *Illuminating Engineer* in 1908 has the following figures for the minimum illumination in various classes of streets, based upon tests in a large number of provincial towns in Great Britain :—

Country roads	...	...	...	0·005 ft.-candles.
Side streets	...	...	...	0·01 " "
Main streets	...	...	...	0·05 " "
Important thoroughfares			...	0·1 " "

If, therefore, we accepted the suggestion that only important thoroughfares should be dealt with, a start might be made by requiring the minimum horizontal illumination to be above one-tenth of a foot-candle.

It is interesting to compare this figure with that obtained from other sources. In the report by A. A. Voysey on the City Lighting in 1908, it is to be noted that in general the curb-lighted important streets did not fall below this value, and in Holborn Viaduct, where it apparently did do so, the minimum value was up to 0·06. Some figures given by Bloch[24] for the high pressure gas and electric lighting of important streets in Berlin reveal minima of a very similar order; the lowest minimum recorded was again about 0·06 foot-candles, the mean values varying from about 0·5 to 2 foot-candles. Similarly the tests in Budapest, mentioned above, led to mean values, both in the gas and electrically lighted streets, varying from about 0·5 to 1 foot-candles.

In the United States it is possible that, in general, a lower order of illumination still prevails, although the standard has risen considerably recently. Some recent tests of the street lighting in Washington showed that the mean illumination by magnetite arc lamps was about 0·06 foot-candles. In this connexion L. Bell has remarked, "In actual amount the London canon in lighting calls for an average of something like a quarter of a foot-candle as against our one-tenth, one-eighth, or one-quarter that amount in the ordinary American city." Possibly one explanation of these figures is the prevalence of the "moonlight schedule," the illumination of moonlight being about 0·002 foot-candles.

Glare, Colour, Steadiness, and Other Matters.

It is generally recognized that the provision of a sufficiently high and uniform illumination in the streets is not the only factor to be considered. Recently the effect of glare has been frequently commented upon, and even in 1908 Haydn T. Harrison (*loc. cit*) suggested the desirability of introducing into street lighting specification a minimum intrinsic brilliancy. Other questions which were mentioned in the Westminster specification included the colour and steadiness of the light

[24] *Illum. Eng.*, Lond., vol. i., 1908, p. 953.

sources; as regards these points we may recall the comment that any exact specification, to be effective, must be supported by reliable methods of testing.[25] In other words, if we assert that a light is to "steady" or to possess a certain colour, it is desirable to prescribe (if possible) methods of testing these qualities in a precise and scientific manner.

One other question that may be mentioned is the desirability of providing all-night lighting. In the United States a "moonlight schedule," according to which the lights were extinguished when the moon should presumably be giving light (if the sky was clear), has been in vogue; but lighting authorities, including L. Bell, pronounce this a short-sighted policy. In Paris, where it has been customary for a section of the public lighting to be extinguished during certain hours of the night, a petition was recently lodged by the police pointing out the desirability of all-night lighting as a means of suppressing crime.

[25] *Illum. Eng.*, Lond., vol. iii., 1910, p. 467.

WHO IS TO ARBITRATE?

Finally there is an important question which will not fail to be raised, Who is to arbitrate in the event of a dispute arising? In the case of the Boston lighting a Board of Arbitration was provided, consisting of the Scientific Heads of Harvard University and the Boston School of Technology, together with a third arbitrator to be chosen by these two.

In this journal attention has repeatedly been called to the need for a Central Authority on Street Lighting to deal with questions of this nature, and reference has been made to the possibility of the Local Government Board or the Traffic Board so acting. But it was also pointed out that, to be effective, such a body must have at its command powerful and impartial expert support.[26]

[26] *Illum. Eng.*, Lond., vol. i., 1908, p. 532.
" " " vol. ii., 1909, p. 579.
" " " vol. iii., 1910, p. 147.

The Hygienic Aspects of Illumination and Illuminating Engineering.

A PAPER having the above title was read by Mr. Leon Gaster at the Institute of Sanitary Engineers (London), on Monday, April 10th, the President, Mr. A. J. Martin, M.Inst. C.E., F.G.S., being in the chair.

In introducing his subject Mr. Gaster recalled an address delivered by Sir James Crichton Browne before the Manchester Sanitary Association in 1902; in this the close connexion between abundant illumination and good health was pointed out and the Italian proverb, "Where the sun does not enter, the doctor comes," was quoted as an illustration of the popular acceptation of the value of good illumination. Mr. Gaster proceeded to refer to the effect of dim surroundings on the health and cheerfulness of workers, and the danger of accidents arising through the outlines of machinery not being clearly visible or plant being allowed to get into a dirty and unreliable condition. The value of good lighting from the industrial standpoint had been emphasized in the Report of H.M. Inspector of Factories for 1909.

A tendency to neglect of personal cleanliness is also met with when the illumination was faulty; in this connexion the lecturer mentioned a recent contribution in *The Medical Officer* by Dr. J. R. Currie, who had shown that want of care as regards cleanliness and defective eyesight usually occurred together in the case of school children. Might not both these conditions arise through a common cause—defective illumination?

Among other questions touched upon by the lecturer were the avoidance of glare, the value of actual measure-

ments of illumination, and the need for additional researches on the physiological influence of light, the effect of illuminants on health and ventilation, &c.

The President, in thanking the lecturer, expressed his appreciation of the need for an impartial standpoint in dealing with lighting questions, and his conviction of the direct interest of such matters to the sanitary engineer. Among others who spoke Mr. J. Eck referred to the amount of carbon dioxide generated by various illuminants, and Mr. T. E. Ritchie laid stress on the necessity for an illumination of at least 3–4 foot-candles for reading purposes.

Several other speakers expressed their keen interest in the paper, and the proceedings were terminated by a hearty vote of thanks to the lecturer.

Photography and the Measurement of Surface-Brightness.

A SOMEWHAT novel application of photometry and measurements of brightness was brought before the Royal Photographic Society in a paper by Mr. J. S. Dow and V. H. Mackinney on March 28th. Attention was drawn to the extreme variations that occur in daylight, and the great difficulty of allowing for these by theoretical exposure tables or actinometers. For example, some tests were described showing how, during three successive days in March, the daylight illumination not only varied within enormously wide limits, but changed progressively in quite a different manner from that which statistical data would suggest. The authors therefore advocated measurements of the actual brightness of the object photographed, and described the use of the Holophane Lumeter for this purpose.

Subsequently some interesting photographs were shown illustrating the application of the method to artificially lighted interiors, which often present special difficulties, even to the expert photographer. Some photographs were next thrown on the screen showing the effect of different exposures in the case of a comparison between the distribution of light from a Holophane reflector and a bare lamp.

The correct relative intensity and distribution of illumination could only be secured by using just the right exposure, ascertained by noting the surface-brightness in different regions of the field of view. It was pointed out that the utmost contrast of light and shade which could be secured in the case of a photographic print was about 30 : 1. Consequently, incorrect exposure would inevitably result in failure to represent correctly the depth of tone in some parts of a subject.

In conclusion, a series of photographs were exhibited showing the results of exposing a plate to a white card, having a surface-brightness of 5 foot-candles, but illuminated in succession by a number of artificial illuminants. The time of exposure was the same in each case, and all the plates were developed simultaneously in the same dish. It appeared that only in the case of daylight was the exposure just right : in the case of the carbon filament lamp, the tungsten lamp, and the incandescent mantle the plate was under-exposed : in the case of the mercury lamps used the plate was over-exposed, though possibly still within the range of good development. From the results of this experiment deductions could be drawn as to how the exposure for different illuminants should be varied in view of their actinic values.

In the discussion which ensued, a number of lantern slides, representing various interiors illuminated by inverted arc lamps, were shown by Mr. T. E. Ritchie, who stated that he had found the Holophane Lumeter instrument of considerable assistance in determining the exposure in each case.

Short Notes on Illuminating Engineering.

From all Sources.

Flash-Light Signals at Sea.

THE use of a flashing light to supplement signalling by whistle blast on board ship is referred to in a recent number of *Popular Mechanics*. It is pointed out that when a ship is steaming in the face of a high wind, there is a possibility that the sound of its whistle will not reach an approaching vessel.

In the daytime the escaping steam will show that the whistle has been blown, and also indicate the length of the blast, but in order to introduce a visual signal at night an electric whistle-blowing apparatus has been installed which automatically causes a light to flash at the same time, and for the same duration, as the whistle blast, thus ensuring that the signal will be seen even if it cannot be heard.

This arrangement is said to have been used successfully on vessels plying on the Great Canadian Lakes.

The Cleaning of Gas Lamps.

HAVE gas engineers ever considered the difference in maintenance costs between any form of square or round lamps, and the best types of inverted lamps?....Just stand and watch a man clean a square or round lantern and note the time it occupies, and then take a similar action in regard to a good inverted lamp on a swan-neck or fixed in a harp. It will be found that the cost of cleaning in the former case is more than twice as much as in the latter.—*Gas*, Jan. 25th, 1911.

Uniformity in Shop Lighting.

THERE has recently been a notable movement among shopkeepers of various districts in the direction of combining together to instal systems of parade lighting, which have been found very satisfactory for attracting customers to a particular district.

It is interesting to note that in America, where this kind of organization has developed to a much greater extent, it is now beginning to be recognized that entire liberty in this respect may lead to discordant systems of lighting, and inharmonious fixtures being used in juxtaposition, if no restriction is put upon the groups of shopkeepers. In this connexion *The Illuminating Engineer* (U.S.A.) refers to two suggestions which have been recently made. The first is that in Kansas City, where some new lighting is to be carried out with flame arcs, the Council should pass an ordinance specifying one kind of light, and requiring all installations to conform to the unit and fixture selected.

The other refers to shopwindow lighting in Johnstown, where it is hoped that the merchants having shops in the main streets will adopt a uniform system of lighting their windows, and will allow them to remain lighted even when the shops are closed, in order to give a more wideawake aspect to the town.

Reference was made in our last issue to the encouragement of evening lighting by the supply companies, who are prepared to charge special rates for shop-window lighting.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

"Household" Holophane Reflectors.

Messrs. Siemens Brothers Dynamo Works Ltd. (Tyssen Street, Dalston, London, N.E.), have issued a list dealing with 14 new types of HOLOPHANE REFLECTORS, which are specially suitable for "HOUSEHOLD" use. These reflectors, we understand, have been specially designed to combine artistic effect with the well-known scientific properties of Holophane glassware. The "Household" Holophane reflectors are made in a variety of shapes, suitable for various styles of electric light fittings. They are satin finished inside, whilst the outer surface is of clear glass. Some of the types are specially suitable for wall brackets, having an arrangement of prisms which strengthens the reflection of light in an outward direction, but which screens a certain amount of light from the wall surface. Another type of reflector is suitable for use on a vertical lamp, such as a table standard or upright bracket lamp; this is particularly suitable for table decorations, &c.

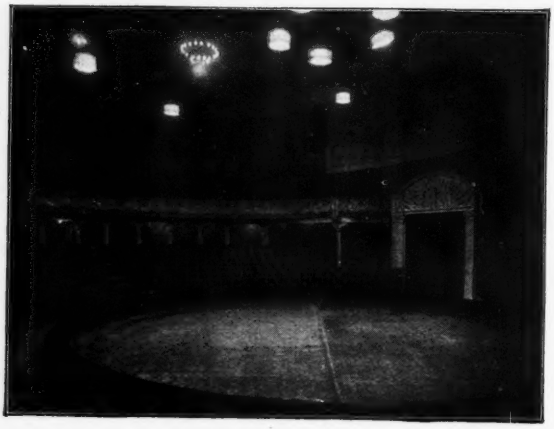
"Howellite" Incandescent Gas Burners.

We have received from **"Howellite" Burners. Ltd.** (22, Farringdon Avenue, E.C.), a price list giving full particulars of the various types of INCANDESCENT BURNERS manufactured by them. Mention may be made of the two-light fitting which has a central Bunsen tube and an adjustable carrier supporting the mantles and globes independently of the nozzles, thus enabling the relative position of flame and mantle to be adjusted.

The special burner for photographic enlargement work, which this firm have brought out, was described in a previous issue (*Illum. Eng.*, vol. iii., Dec., 1910, p. 751).

Osram Lamps at Hengler's Circus, Glasgow.

The view of the lighting at Hengler's Circus, Glasgow, which we reproduce here, is an illustration of the use of electric lighting in places of entertainment, where its ease of manipulation has given it a strong position. The lighting bill of any large entertainment hall is, of course, a matter for serious consideration, and it is therefore not surprising to note the general adoption of metal filament lamps for this purpose.



The installation in question has been carried out with Osram lamps supplied by the **General Electric Co.** (71, Queen Victoria Street, London, E.C.); a feature of interest is the frequent use of ten 1000-watt lamps. The total consumption of energy is stated to be nearly 20 kilowatts.

The "Crab" Patent Globe-Holder.

The ingenious device in the accompanying illustration is intended as a carrier of globes used with electric or gas lamps. It is claimed to have two principal advantages: firstly, the supporting screws do not touch the glass, and this helps to avoid the risk of breakage; secondly, the globe can be fixed

or removed with one hand only, and without touching the screws. When the "Crab" holder has been sprung on to the neck of a globe, it virtually provides the glass with three slotted lugs; these can be readily attached to the fixing screws on the outside of the shade-ring by simply placing the lugs on a level with the screws and giving a slight turn to the right. The action is similar to that of a bayonet joint in a lamp-holder.

Osram Lamp Tests.

The General Electric Co. (67, Queen Victoria Street, E.C.) have sent us a facsimile of a certificate received from the National Physical Laboratory, showing that all of 9 lamps tested burned for 2,000 hours, and gave an average candle-power of 26·6, with an average consumption of 1·39 watts per candle during the life test.

An extract from the official records of Hammersmith Borough Council shows that of 75 Osram lamps in use the AVERAGE LIFE per lamp was over 3,600 HOURS.

Attention is drawn to the REDUCTION IN PRICE of 200, 400, and 600 c.-p. lamps, which takes effect from April 15th.

The British Westinghouse Electric and Manufacturing Co., Ltd. (Trafford Park, Manchester), announce that from April 15th the prices of their high candle-power "AURIGA" METAL FILAMENT LAMPS will be considerably reduced.

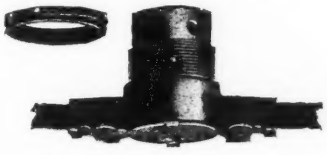
We are informed by the **Adams Watkin Co., Ltd.** (36, Victoria Street, S.W.), that they are about to put on the market a METAL FILAMENT LAMP, British made, and possessing certain novel features which have been patented.

Iron and Steel Institute.

The Annual Meeting of the Institute will be held at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, 11th and 12th of May, 1911, commencing each day at 10.30 A.M.

Messrs. Siemens Brothers Dynamo Works, Ltd. (Tyssen Street, Dalston, N.E.), inform us that they have reduced the list prices of their "ONEWATT" LAMPS of 200 c.-p. and 400 c.-p., and that the prices of these, in all voltages, are now 9*s.* and 17*s.* each respectively. The price of the 100 c.-p. lamp remains unchanged at 4*s.* 6*d.*

Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen Street, Dalston, N.E.), have sent us a copy of their special catalogue of CORONATION ILLUMINATION DEVICES. Besides containing a large variety of the usual mottoes, crests, &c., the list includes several neat and attractive shades and lanterns for use on ordinary pendants, and particulars are also given of the "Bro-ite" strip which Messrs. Siemens Bros. are supplying for rapid wiring in illumination work. The accompanying illustration shows this



system with a lamp-holder in position, but without the rubber sleeve covering supplied for use in exposed positions. We note that Messrs. Siemens are prepared to quote for complete illumination schemes, but that, in accordance with their usual practice, they will sublet the wiring and erection to local contractors.

Other lists received from :—

Messrs. Edison & Swan United Electric Light Co., Ltd. (36, Queen Street, E.C.), CARBON FILAMENT LAMPS of all kinds; **Messrs. Cryselco, Ltd.** (Kempston Works, Bedford), TUNGSTEN LAMPS; **Messrs. British Westinghouse Electric and Mfg. Co., Ltd.** (Norfolk Street, Strand, W.C.), a booklet on MOTOR CONTROL and a leaflet descriptive of the WESTINGHOUSE-LEBLANC CONDENSING PLANT; **Messrs. A. E. G.** (Berlin) an exhaustive catalogue of PROJECTORS AND SEARCHLIGHT APPLIANCES; **Messrs. Glyco Metal Co., Ltd.** (8 and 9, South Parade, Manchester), ALLOY BEARING METALS.

Messrs. The Sun Electrical Co., Ltd. (118–20, Charing Cross Road, W.C.), send us a pamphlet giving particulars of the various accessories—SWITCHES, PLUGS, CEILING-ROSES, &c.—used in connexion with their "KALKOS" TINNED TUBE SYSTEM. The "Kalkos" switch is specially designed to be water-tight and air-tight, and all live parts are entirely encased in porcelain. The knob of the switch is automatically earthed when the cover is screwed on, and the whole has been designed with a view to satisfactory working on a completely earthed system.

From the same firm we have received an advance pamphlet of coronation illumination devices, and details of the "Suncolite" strip.

New Books.

Messrs. Constable & Co. (10, Orange Street, Leicester Square, W.C.) inform us that they are about to issue the first two volumes of a series of electric installation manuals "By Practical Men for Practical Men." The prices will range from 1*s.* net to 2*s.* net. The first two volumes to appear will deal with (1) motors, secondary batteries, &c., (2) arc lamps and accessory apparatus.

Messrs. F. & C. Osler, Ltd. (100, Oxford Street, W.), inform us that they are exhibiting examples of their ELECTRIC LIGHT FITTINGS at the Building Trades Exhibition at Olympia (Stand No. 168).

Some Publications Received.*

Report of the National Physical Laboratory, 1910.—In the Photometric Laboratory, we notice, the work of standardizing the electric sub-standards has been continued, and it is anticipated that good results will be obtained this year with lamps recently supplied.

An investigation has been in progress on the visibility of ship's lights, the relation between intensity and distance, &c.

Transactions of the Illuminating Engineering Society (U.S.A.).—Two papers are included in which different aspects of the effect on the eyes of artificial illumination are discussed. A detailed account is also given of the lighting of a large store.

Journal of the Franklin Institute.—A paper by G. S. Merrill gives an elaborate comparison of the various properties of metal filaments, with diagrams and photographs.

Variations in the Polarization of Sky Light are dealt with in a paper by H. H. Kimball.

Verwaltungs-Bericht des Deutschen Museums.—The annual report for the session 1909–1910 of the national museum at Munich.

Health and Hygiene.—A letter to the members of the Incorporated Institute of Hygiene, in which various subjects are discussed from the hygienic point of view.

Das Acetylen. By Prof. J. H. Vogel. An up-to-date work dealing with the generation of Acetylene, the chemical processes involved, and its applications to lighting, heating, and welding.

Illuminanti ed Illuminazione. A reprint of a paper by Prof. S. A. Rumi, dealing with various aspects of illumination.

High Efficiency Electrical Illuminants and Illumination. By R. W. Hutchinson, Jun. A book dealing with the various modern sources of light, with some considerable space devoted to the principles of illumination and photometry.

The Faraday House Journal.—Besides containing a record of the doings of Faraday House students, this attractive little pamphlet has several short articles on practical points of interest to electrical engineers, these being contributed by old students of the Institute.

We have received a copy of a brochure entitled *The Plague*, from the pen of our distinguished Hon. Member, Dr. Moeller, President of the Second International Congress of Hygiene held at Brussels last year.

Among other publications we have also to acknowledge the receipt of the following:—*Journal of the Royal Society of Arts, Journal of the Institution of Electrical Engineers, Journal of the Society of Architects, Proceedings of the Faraday Society, Journal of the Royal Sanitary Institute, Proceedings of the American Institute of Electrical Engineers, The Physical Review, American Chemical Journal, Proceedings of the American Philosophical Society, American Chemical Journal, Journal of the Röntgen Society, Proceedings of the Tokyo Mathematico-Physical Society.*

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* To some of these we hope to refer in greater detail shortly.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

The last number of the *Transactions* of the Illuminating Engineering Society (U.S.A.) again contains several interesting contributions. A. E. KENELLY deals with the **Vanishing of Flicker** with increasing speed and illumination, and deduces a number of conclusions regarding the physiological peculiarities of the eye (for example, that the central region is more sensitive to flicker than the surrounding portion). P. W. COBB describes some **Experiments on Glare,** and arrives at some unexpected results; thus in some cases, a frosted lamp, with the light spread out, apparently affected the retina even more than a bare lamp, but this was apparently under exceptional conditions. In an editorial in *The Illuminating Engineer* (N.Y.) it is suggested that methods of testing glare based on visual acuity are unreliable, since they do not give a correct measure of the actual inconvenience and possible injury to the eye. Among other articles in this journal we note that W. C. HUBBARD describes three installations in a drawing office, a plating room, and a stamping factory where mercury vapour lamps are said to have been used with good effect. H. E. IVES points out that a **Yellow Glass** can often be used for artistic reasons with artificial illuminants so as to modify the colour and yet not to involve too great a loss in efficiency; the blue region of the spectrum, which is mainly cut off by such glass, really forms an inconsiderable portion of the total light produced.

A third interesting illustrated article deals with the demand among American cities for **Decorative Public Lighting;** some striking illustrations of lamp-post designs are given. There is also an account of the **National Association for the Conservation of Vision.** This association receives the combined support of lighting experts and oculists, its avowed object being to promote the study of the effects of illumination on eyesight.

We may next note an interesting account of the **Artificial Lighting of a Cathedral** in New York (*Elec. World*, N.Y., April 13th). Photographs are shown side by side contrasting the appearance of the same portion of the interior lighted respectively by daylight and by artificial means; the method adopted consists largely in the use of concealed strip-lights, by the aid of which the chief architectural features are shown up in relief and the illumination is concentrated at points of central interest, such as the altar.

W. VOEGE (*J.f.G.*, April 1st) describes some experiments undertaken with a thermopile in order to compare the **Heat given out by Various Illuminants**; a table is presented showing the results for a number of lamps with and without obscuring globes.

Mention may also be made of an article in the *Times Engineering Supplement* for April 26th, discussing the functions of **Portable Miner's Lamps,** and a paper before the Institute of Sanitary Engineers by L. GASTER (*J.G.L.*, April 18th) in which a number of questions of interest to the sanitary engineer, such as the **Influence of good Illumination on Health, Spirits, and Cleanliness,** are discussed.

Finally, reference may be made to an article in the *Am. Gaslight Journal* describing the ingenious use of mirrors for advertising purposes and display in shop-windows.

ELECTRIC LIGHTING.

There have not been very many articles dealing with novel points in electric lighting.

Mention may be made of several serial contributions in German journals in which recent patents on **Metallic Filament Manufacture,** the attachment and method of looping filaments to supports, &c., are discussed.

B. MONASCH also contributes a readable summary of progress in the subject. An interesting statement is that drawn wire tungsten filaments show similar peculiarities to tantalum ones on alternating current; it would seem, therefore, that this effect is characteristic of a drawn wire.

W. S. AUSTIN (*Elec. World*, N.Y., April 6th), discusses the **Electric Lighting of Freight Yards** by flame arc lamps, and another number of the same journal con-

tains an interesting account of the travelling searchlights being used in the United States Army. These are mounted on motor vehicles which can mount rough and steep slopes, and are devised with a view to rapid action in any desired direction.

A. PUGLIESE (*Atti della Assoz. Elettr. Italiana*, March) describes the new **Carbone Enclosed Flame Arc Lamp**. A feature is the provision of certain cooling zones remote from the arc, in which the fumes can deposit without prejudice to the illumination yielded by the lamp.

Finally, attention may be called to the series of articles on **Electric Street Lighting** recently contributed by A. Scheible in the *Electrical Review* of New York. The first article is mainly historical, containing some account of the early use of artificial light in the streets of Rome, &c., and of the origination of the "moonlight schedule." Further articles deal with the development of arc lamps and, more recently, illumination by high candle-power incandescent lamps; special stress is laid on the need of avoiding glare and the use of appropriate globes and reflectors.

GAS, OIL, ACETYLENE LIGHTING, &c.

Among the striking events of the last month has been the presentation by the Gas Light and Coke Co., and the various Electricity Supply Companies, of a **Joint Lighting Specification** for the Borough of Holborn. It is suggested that the streets should be illuminated partly by gas and partly by electricity. The incident is regarded as setting an important precedent in the way of concerted action between representatives of gas and electric lighting, and the matter is commented on in many gas and electrical journals.

Another question still keenly discussed is the **Standard of Calorific Power** to be required from town gas, and a recent article by A. GREBEL on this subject is quoted (*J.G.L.*, April 25th). The present standard adhered to by the Gas Light and Coke Co. is given as 450 B.Th. U. net, and it is suggested that this should certainly not be exceeded. An illustration of the trend of events in this respect is the passing of the illuminating power test at Preston.

Among other interesting articles during the past month mention may be made of the **Artificial Illumination by Gas of Covered Tennis Courts** in Dulwich; this, however, is fully described elsewhere in this number. A. SCHEIBLE (*Elec. World*, N.Y., March 30th) discusses some difficulties in applying the indirect method of illumination to gas lighting, and show how they may be overcome; when a moderate illumination of the ceiling is required, the method is easily applied; but if it is desired to light up the ceiling strongly, and to bring the sources close to it, some little attention to detail is necessary. W. S. FARROW (*Am. Gaslight Journal*, April 17th) deals with **Sign and Special Lighting** by gas. He refers to the field in lighting advertisement signs, porch-lights, and lamps outside doctor's houses, &c.

There is a serviceable summary given of the report of the Home Office expert on the **Hawes Railway Disaster**, where a stream of gas was apparently ignited among the damaged carriages. Several recommendations, such as the strengthening of the cylinders in which the gas is stored, the provision of special disconnecting cocks, &c., are made (*J.G.L.*, April 18th; *G.W.*, April 1st).

In connexion with oil, acetylene, and other methods of lighting we may again note the paper by E. SCOTT SNELL on **Petrol Air Gas Lighting**, now more fully reported. An interesting suggestion is that the mixture of petrol and air ought to contain at least 6 per cent of petrol in order to preclude the chance of an explosive mixture being generated. The *Progressive Age* (April 15th) contains a short and readable article summarizing the chief systems of oil-gas, &c., and a recent number of *Acetylene* contains a précis of recent Home Office Regulations on the storing and use of the gas.

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
J. G. L.—*Journal of Gaslighting.*
T. I. E. S.—*Transactions of The Illuminating Engineering Society (United States).*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

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Black, N. M. Artificial Illumination as a Factor in producing Ocular Discomfort (*T.I.E.S.* March).

Cobb, P. W. Physiological Points bearing on Glare (*T.I.E.S.*, March).

Editorials. Lamp Posts and Lamp Columns (*G.W.*, April 22).
Special Incandescent Lighting for Battleships (*Elec. Review*, N.Y., March 18).
Commercialism in Scientific Literature—Glare and Visual Acuity, &c. (*Illuminating Engineer*, N.Y., April).

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Hubbard, W. C. Three Interesting Problems in Industrial Lighting (*Illuminating Engineer*, N.Y., April).

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Kenelly, A. E. Flicker on Fixed and Rotating Targets (*T.I.E.S.*, March).

Marshall, A. J. Ocular Research Suggestions (*Illuminating Engineer*, N.Y., April).

Law, C. L., and Marshall, A. J. The Lighting of a Large Store (*T.I.E.S.*, March).

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Voege, W. Ueber Licht- und Wärmestrahlung der kunstlichen Lichtquellen (*J.f.G.*, April 1).
Miner's Lamps (*Times Engineering Supplement*, April 26).
Tables for correcting the Harcourt Standard (*J.G.L.*, March 28).
Decorative Public Lighting (*Illuminating Engineer*, N.Y., April).
The American Association for the Conservation of Vision (*Illuminating Engineer*, N.Y., April).
Lectures on Illumination (*Illuminating Engineer*, N.Y., April).
Illumination of the Cathedral of St. John the Divine, New York (*Elec. World*, N.Y., April 13).
The Lighting of Hospitals (*Acetylene*, April).
Mirrors and Lights for Advertising (*Am. Gaslight Journal*, April 10).

ELECTRIC LIGHTING.

Austin, W. S. Freight Yard Lighting (*Elec. World*, N.Y., April 6).

Editorial. Electric Street Lighting (*Elec. Review*, N.Y., April 1).

Monasch, B. Die Entwicklung der Glühlampentechnik (*E.T.Z.*, March 30).

Pugliese, A. La nuova lampada a fiamma a lunga ascensione della A. E. G. [T. L. Carbone]: (*Atti della Assoc. Elettr. Italiana*, March, 1911).

Scheible, A. Electric Street Lighting (*Elec. Review*, N.Y., April 1, 8, 15).
Electric Field Search Lanterns in the United States Army (*Elec. World*, N.Y., April 13).
Neuerungen auf dem Gebiete der elektrische Beleuchtung (*J.f.G.*, April 15).
Fortschritte der Glühlampen-industrie (*Z.f.B.*, March 10, 20, April 10, 20).

GAS, OIL, ACETYLENE LIGHTING, &c.

Böhm, C. R. Die seltenen Erden mit besonderer Berucksichtigung der Thorium-industrie (*Z.f.B.*, April 10).

Busch. Uber Luftgas (*J.f.G.*, April 8).

Editorials. Westminster Lighting under Test (*J.G.L.*, April 18).
A Novel Partnership for Holborn (*J.G.L.*, April 18).
Excessive Calorific Power Standards (*J.G.L.*, April 25).

Farrow, W. S. Sign and Special Lighting by Gas (*Am. Gaslight Journal*, April 17).

Grebiel, A. The Passing of the Illuminating Power Test (*J.G.L.*, April 25).
Upright *v.* Inverted Burners (*G.W.*, April 15).

Leybold. Verminderung der Unfälle im Rohrnetzbetrieb und bei der strassenbeleuchtung (*J.f.G.*, April 8).

Othner. Beitrag zur Frage der Strassenlaternenfernzündung (*J.f.G.*, April 22).

Scheible, A. Gas Lamps *v.* Indirect Lighting (*Elec. World*, N.Y., March 30).

Scott Snell, E. Petrol Air Gas (*J.G.L.*, April 18.)

Upton, W. Some Modern Aspects of Gas (*G.W.*, April 1).
Westminster Public Lighting (*J.G.L.*, April 18).
The Hawes Disaster and Gaslighting (*J.G.L.*, April 18; *G.W.*, April 1).
Centrally hung Gas Lamps in the City (*J.G.L.*, March 28).
Gas and Electricity Classes in Rome (*J.G.L.*, March 28).
High Pressure Gas Lighting in Paris (*J.G.L.*, March 28).
Tennis by High Pressure Gas Lighting (*J.G.L.*, April 11).
Transportable Illuminating Gases (*Prog. Age*, April 15).
The Essentials of a good Atmospheric Gas Burner (*Acetylene*, April).
Home Office Regulations on Acetylene (*Acetylene*, April).

COUNTRY SCHOOLS

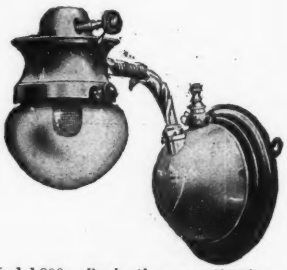
CAN BE QUITE AS EFFECTIVELY and much more cheaply LIGHTED THAN TOWN SCHOOLS by means of the

"BLANCHARD"

HIGH POWER SAFETY INVERTED INCANDESCENT OIL LAMP.

This new oil lamp enables every Country School to be abundantly illuminated, the cost for 100 candle power being only **one penny for 16 hours.** The light is better for the eyes than Gas or Electricity.

THERE IS NO SMELL OR SMOKE.



Model 1107.— Length overall 24 ins. Weight, when full, 10 lbs.

Model 800.—Projection overall 14 ins. Weight, when full, 6½ lbs.

These lamps can be suspended from hooks in the ceiling in any desired position, or fixed to the wall by means of a detachable hook, enabling them to be removed very easily.

Prices and particulars from

THE GAS ECONOMISING & IMPROVED LIGHT SYNDICATE LIMITED,

151, Farringdon Road, LONDON, E.C.

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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

The Second Session of the Illuminating Engineering Society.

THE Annual General Meeting on May 9th, which is fully reported on pages 333-337, marks the termination of the second session of the Illuminating Engineering Society. The record of the work of the Society during this period is summarized in the Report of the Council (pp. 338-344). The results of the second year's work have not only given great satisfaction to members, but have attracted a considerable amount of attention outside the Society. The course of development was most happily described by the President in the course of his remarks at the Annual Meeting, and has coincided exactly with the anticipations formed at the commencement of the first session. At that time the Society was, in a sense, on trial. Outsiders were not unnaturally in some doubt as to what course it would pursue, and even members would have found it difficult at the moment to state with any precision what its immediate functions would be. It was, however, felt that a new Society of this kind, having its career before it, and having as yet but a small band of supporters, should naturally deal with general questions first; in this way the interest of the outside public would be roused, and many trains of useful investigation would be suggested, to which the Society could return at a later stage. On the other hand, to have attempted to deal with specific practical questions at the outset, before the influence of the Society had become known and recognized, and before members themselves had gained a sufficient knowlege to deal effectually with such points, would have been unquestionably unwise. The Society, as the President happily phrased it, has been necessarily engaged upon "a career of self-education": it must therefore proceed on the usual sound educational plan of building up a substantial broad

general foundation before attending to details.

This is exactly what has been done. In the First Session such questions as the Nature of Glare and the Measurement of Light and Illumination—two fundamental points in illuminating engineering—were dealt with, and the influence of these discussions can be clearly traced in many of the papers on matters connected with illuminating engineering which have since appeared. When, in the Second Session, the Society proceeded to more practical applications, such as School and Library Lighting, the intensity of illumination required and its measurement, and the avoidance of glare, proved to be the two most fundamental points underlying the discussion. As a sequel to this preliminary study of school and library lighting, two committees have been appointed which, it is anticipated, will study these questions in greater detail than the Society as a whole could do. They will carry on investigations suggested by the previous discussion, and at a later stage will eventually present before the Society the additional information which has been collected; they will also endeavour to frame some tentative recommendations of a general nature based on the discussion that has so far taken place.

The membership of the Society has shown a very satisfactory increase to over 270 during the session, including most of the leading authorities in lighting matters in different parts of the world. But it may be suggested that the number of supporters *outside* the ranks of the Society has grown still more rapidly. The Illuminating Engineering Society, as the Report of the Council points out, stands in a unique position as a link between the expert and the non-technical public. In the discussions referred to, it has already obtained the valued co-operation of such bodies as the Library Association, the Association of Medical Officers of Schools, the Association of Teachers in Technical Institutions, and other scholastic authorities, which sent representatives to participate in the proceedings. Again, in sending delegates to "Second Congrès International des Maladies Professionnelles," it was the means of interesting in illumination many authorities concerned with industrial hygiene. Another feature has been the number of educational papers read by members of the Illuminating Engineering Society before other bodies. By a policy of this kind the Society is continually making its work known in influential quarters, and its circle of supporters, within and without the ranks of membership, is continually increasing. In passing, we may also draw attention to the accession of strength in the membership of the Council, which has recently been privileged to secure the distinguished support of a number of well-known medical and lighting authorities. The Council, however, still desire to see the Architectural Profession more fully represented. It may be hoped that others will follow the example of the distinguished President of the Royal Institute of British Architects, Mr. Leonard Stokes, who has already given his support as a Vice-President of the Society.

Meantime it is hoped that all will do their best to extend the influence of the Society. If each member will endeavour to secure the support of one friend only our membership will soon show a substantial increase, and we trust that full use will be made of the Form of Application for Membership inserted in this number.

In entering upon its Third Session the Society will naturally proceed somewhat further along the path from general discussions to more practical applications. A glance at the suggestive list of subjects which has been prepared for the guidance of members, and is published on page 345 in this number, will serve to show the rich

field for discussion before us. The work of the Council, in preparing the programme for the next session, would be considerably lightened if members would take advantage of this invitation to send in papers *at an early date*, so that provision can be made in good time to secure representative and interesting discussions.

In conclusion, we should like to emphasize the very great privilege which the Society has enjoyed in having Professor Thompson for its President during these first two critical years of its existence. The Council, in unanimously nominating Professor Thompson an Honorary Life Member, has endeavoured to make some slight recognition of his services to the Society; every member must appreciate the generous amount of attention he has devoted to the Society's affairs and the unique benefit of receiving his distinguished support.

Bank and Office Lighting.

The ease with which work can be carried on in a bank or other kind of office depends very greatly on the illumination provided. There should be no need to emphasize the importance of good lighting in such cases. Even the most trivial piece of work is rendered difficult if one cannot see properly—if, for example, documents cannot readily be seen and selected from a drawer or cupboard, or if the illumination on a desk is not sufficient to write by.

Perhaps, however, the most important section of office illumination is desk lighting. Many old-established institutions date back to days when artificial means of illumination were comparatively limited. Consequently, we sometimes find that the primitive conditions of past years are still suffered to remain; even when new methods are employed the lights are insufficient and badly placed, and the work suffers in consequence. The question of artificial lighting, it may be pointed out, is of exceptional importance in London. In the City districts, in particular, where space is becoming increasingly valuable, tall buildings and narrow streets obstruct the access of daylight considerably, so that artificial light has to be used during a large part of the day. We also suffer from occasional fogs, and on a dull day the lights in many City offices must be used continuously. How essential, therefore, that the artificial illumination, on which so much reliance is placed, should be thoroughly satisfactory!

There are a number of points which call for special attention in desk lighting. The actual illumination of a book must be sufficiently high and uniform. In the case of many of the existing fixtures this is not the case, the illumination in some regions being excessive and in others much too low. The lights must also be placed so as to be completely screened from the eyes, and to avoid direct reflection into the eyes from the shining surface of books or papers.

Such defects are not infrequently prejudicial to the eyes. Dr. Louis Bell, for example, recently remarked, "I have been in a counting room where I found every clerk with signs of bad eyes," and many years ago a famous oculist pointed out to the writer that certain defects commonly attributed at that time to electric lighting were really due to the misuse of lamps in positions within the direct range of sight.

It is possible that many employers are not sufficiently alive to the serious nature of such defects in vision. Few faculties are so indispensable as sight, and, once affected prejudiciously, it is difficult to regain. Yet the deficiencies in lighting mentioned above can usually be remedied by the expert with sufficient knowledge and experience, and a few simple alterations will also often lead to a considerable saving in the lighting bill.

But it is not on this last point that we desire to lay most stress. The amount spent in lighting by a bank or

kindred great institution is usually a trifle in comparison with the issues involved in the actual work of the employees. Any small expense entailed in putting the lighting on a sound footing would be more than compensated for by the greater ease and reliability with which the important daily work is carried out. The responsibility of these engaged in banking and financial business, even in a humble capacity, is often considerable. A momentary absence of mind or trifling slip in a figure may have most serious consequences. The effort of writing continuously during the day, or reading the often indecipherable handwriting of others, is great, and the necessity for perfect accuracy imposes a certain nervous strain. It is therefore essential that everything should be done to prevent such mistakes, and to make the conditions of work satisfactory. As the result of discussion among various authorities we now know more fully the requirements of these cases and employers are in a much better position to gain good advice than they were a few years ago. We consider that proper lighting is one of *the most important* requirements in this connexion, and feel sure that employers who carefully consider this matter will inevitably be led to the same conclusion.

The Coronation Illuminations.

The President, in his remarks at the Annual Meeting of the Illuminating Engineering Society, referred to the coming coronation illuminations. These are expected to be on an unprecedented scale, and it will be interesting to see how far they constitute an advance in quality from the decorative and illuminating engineering standpoint.

There is no concealing the fact that such displays have often been carried out in a very chaotic and unscientific manner in the past. Individual bright illuminations were put up without regard to their surroundings, so that the effect was that of a number of scattered units rather than a complete harmonious whole.

Another well-founded objection, which has often been urged against such illuminations, is based on the striving after excessive brilliancy and the production of innumerable bright spots of light rather than broad masses of colour. It may perhaps be suggested that future progress will lie rather in the direction of illuminating large surfaces, such as the outside of important buildings, &c., with moderate intensity and the judicious blending of colours so as to resemble more closely the scenic display on the stage. An interesting instance of co-operation between the architect and the engineer in producing effects of this nature was afforded by the illumination of the Pittsburg Memorial in the United States, recently described by Mr. W. Bassett Jones, and referred to in these columns.

There is one other possibility in spectacular lighting which does not seem to have received the recognition it deserves, namely, the illumination of imposing buildings, monuments and memorials of national interest, &c. During the night time, people walking in the streets have usually a little more leisure to devote to such objects, and they might well be rendered more easily visible and attractive.

An instance in point occurs to us in the magnificent newly unveiled memorial to Queen Victoria. There seems a need for some effective means of illuminating the white carving by concealed distant lights so as to throw it into bold relief from the surroundings and render the whole a prominent object from different parts of the Park. We do not know whether any such provision is being made but we venture to suggest that this plan has been followed in some instances with advantage on the Continent; the white statues, when illuminated artificially, become prominent objects standing out boldly from their darker surroundings.

LEON GASTER.

Review of Contents of this Issue.

MR. A. P. TROTTER (p. 325) contributes a discussion of Mr. Harrison's suggestions regarding **Illuminating Engineering Nomenclature.** In the course of this he reviews the suggestions that have been made by Prof. Blondel, Weber, and others regarding the meanings to be attached to such terms as surface brightness (flächenhelle), intrinsic brilliancy, &c., and weighs the merits of the proposals that have been brought forward for distinguishing between illumination from "primary" and "secondary" sources.

Following this is a short article dealing with the **Illumination on Tube Railways,** in which some results obtained by PROF. J. T. MORRIS are tabulated. A diagram is given showing the fluctuation of illumination during a journey from the Bank to Shepherd's Bush on the Central London Railway, and some conclusions are drawn as to the average value of illumination required.

On page 329 will be found a review of the illuminating engineering movement in America under the title of **A Year's Progress in Illuminating Engineering.**

The Lighting of the Horniman Museum is described on page 330, and attention is drawn to a number of points of interest to the illuminating engineer. The method adopted of lighting the exhibits contained in wall-cases under the balcony, where the general illumination of the hall does not suffice, is described in detail, and special mention is made of the lighting of the aquarium corridor, where the need for specially good illumination of the tanks is pointed out.

The section devoted to the *Transactions* of **The Illuminating Engineering Society,** opens with an account of the **Annual General Meeting.** The adoption of the Report of the Council was moved by MR. T. E. RITCHIE.

MR. F. W. GOODENOUGH, in proposing a vote of thanks to the President, emphasized the debt of gratitude which the Society owed to Prof. Thompson; and MR. R. J. WALLIS-JONES, in seconding the motion, referred to the able way in which their President had guided the discussions of the past session.

THE PRESIDENT, in replying, briefly reviewed the work of the Society, and pointed out the permanent value of many of the results arrived at in connexion with the discussions on Library Lighting and School Lighting.

The proceedings closed with votes of thanks to the Council and Officers and to the Royal Society of Arts for permission to use their Hall for the meetings.

On page 338 will be found the **Report of the Council** for the Session just closed. Reference is first made to the continued growth of interest in the illuminating engineering movement, and also to the demand now arising for better educational facilities in this direction. The general survey of progress concludes by drawing attention to the recognition in official quarters of the importance of Industrial Lighting.

The Report proceeds to review the work of the Society during the past session, referring to the increase in membership and detailing the special features of the meetings. Special attention is drawn to the International attitude of the Society, and the way in which it has been able to co-operate with other bodies both at home and abroad. A brief statement of the financial position of the Society follows, and mention is made of the Committee appointed to consider the drafting of a Standard Specification for Street Lighting.

The Report concludes by drawing attention to the many practical problems waiting to be solved, and to the encouraging prospects of the Society for the future.

A list of subjects on which papers are invited for next session appears on

page 345, and this is followed by the Balance Sheet.

The **List of Officers and Members of the Society,** corrected up to May, 1911, occupies the following pages, and the account of the **Discussion on Interior Illumination and the Reflecting Power of Walls and Ceilings** which took place on April 24th is continued on page 360.

MR. A. P. TROTTER opened the discussion by drawing attention to the possibility of treating the subject mathematically, and gave a formula for this purpose; but he pointed out that owing to the difficulty of ascertaining all the conditions, it was often desirable to have recourse to experimental work, and he thought satisfactory measurements could be made with small model rooms.

MR. JUSTUS ECK agreed with Mr. Harrison that some distinction should be made between primary and secondary illumination, and he suggested the adoption of the term "luminosity" for the latter. He thought that manufacturers were generally willing to give distribution curves and other information with regard to their lamps to *bona fide* illuminating engineers.

MR. V. H. MACKINNEY thought that the importance of scientifically designed diffusing globes or reflectors had hardly been sufficiently emphasized, and quoted a typical example in which a saving of 56 per cent in energy consumption could be obtained by the use of a suitable reflector. He also submitted a table and some curves which had been worked out experimentally, and by which it was possible to calculate the increased illumination necessary in a room with given conditions of wall paper, as compared with that required for a similar theoretical case of white walls and ceiling.

MR. T. E. RITCHIE, speaking of the indirect system of arc lighting, did not think it should be described as shadowless, but rather that the shadows were soft and agreeable; in this respect the effect was more like daylight. Some illustrations of rooms devoted to modelling, &c., and lighted by inverted lamps are also given. The whole question of interior illumination called for much closer co-operation between the lighting engineer and the decorative craftsman.

MR. J. G. CLARK suggested that some simple approximate rule for determining the amount of illumination required in a room with a particular scheme of decoration, would be useful.

MR. W. R. RAWLINGS pointed out that the problem of room lighting was complicated by the fact that each particular case had to be dealt with on its own merits, on account of the different shapes of rooms the curtains, pictures &c., on the walls, and the use to which the room was to be put.

MR. J. HEWITT emphasized the importance of the question of glare, and pointed out the necessity of getting from the architect before-hand definite details of the scheme of decoration to be employed in a building.

MR. J. DARCH suggested that wall-paper manufacturers might be induced to print on the back of samples a figure, determined experimentally, for the average co-efficient of reflection. He also disagreed with several of Mr. Harrison's suggestions as regards nomenclature.

MR. J. S. DOW discussed Mr. Harrison's use of the term "Lumen," and suggested that the expressing of surface brightness in terms of foot-candles was often convenient, and was satisfactory provided that in recording results a clear distinction was made between measurements of illumination and surface brightness.

The report of the discussion concludes with the remarks of the Chairman and the replies of the authors of the papers.

An interesting **photograph of the National Gallery taken at night** is reproduced on page 374. It is pointed out that a view of this kind enables one to judge how much the artificial illumination of our public buildings would be improved if the distracting glare of street lamps and other sources were absent.

On page 375 will be found a number of **Short Notes on Illuminating Engineering,** and these are followed by the usual **Trade Notes** and **Review of the Technical Press.**

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

The Nomenclature of Primary and Secondary Sources of Light.

By A. P. Trotter.

It is highly important that the terms used in optical science should be carefully defined, and it is equally essential that those employed in illuminating engineering should be clearly agreed upon. As in mechanical and electrical work, the scientific and the engineering vocabulary may differ slightly, and the mode of measuring the quantities may not be the same. But there must be no doubt of the meaning of any term.

The vocabulary at our disposal is so large that there is no need for coining new terms; on the contrary, some words may, perhaps, be excluded from scientific literature. Mr. Haydn Harrison has done well to call attention in his Paper read before the Illuminating Engineering Society* to illuminating units and their definitions, and those who do not altogether agree with him will appreciate the opportunity which is afforded for discussing the subject.

"The emanations from a light source" is too wide a definition of *light*. "Radiant light," wrote Lord Kelvin,† "is light if we see it; it is not light if we do not see it." *Light* is, I think, sufficiently defined as "visible radiation." I cannot agree with Mr. Harrison in coupling *luminosity* and *luminous intensity*. *Luminous intensity* should be the second quantity to be defined. As a matter of fact, the expression, though generally used in France, is seldom found in English, because we prefer the term *candle-power*. There are several ways of defining this quantity, but as there is no dispute about its meaning I will not stop to consider them.

The third quantity to be defined is *illumination*. "Remuneration," defined according to Mr. Harrison, would be "the extent to which anybody is remunerated." This is undeniable, but does not carry an engineer much further. In making definitions it is sometimes well to define the abstract idea independently of the measurable quantity. *Illumination* might perhaps be defined simply as the reception of light on a surface. This prepares us for similar definitions of the correlative idea of *brilliance*. The idea having been defined, a good quantitative definition of the British unit of illumination is "the illumination produced by one candle-power at a distance of 1 ft. on a surface facing the source of light."

Such a definition does not appeal to the mathematical mind. Dr. Rosa says* that illumination is the flux-density or flux per unit area on the surface where the luminous flux is received, and gives us the unit, lumens/cm^2. Blondel in 1894,† in his valuable article on 'Photometric Magnitudes and Units,' gives a quantitative definition. "The illumination (*éclairement*) e at a point of a surface is equal to the ratio of the luminous flux which

* *Illum. Eng.*, Lond., May, 1911, p. 280.

† 'Popular Lectures and Addresses,' i. 291.

* *Bulletin*, Bureau of Standards, Washington, vi. 546.

† *La Lumière Electrique*, Sept., and *The Electrician*, xxxiii. 634.

falls on a small element of surface to the area of this surface, $e = d\Phi/ds$," or "the illumination produced on a surface of 1 sq. metre by a uniform flux of the lumen." These are not quite the kind of definitions one would offer to a borough engineer for street work. They are rather like measuring rainfall as the ratio of the grammes of water to the area in square centimetres. The lumen is a valuable unit, but I do not think that English engineers are quite ready for it.

The idea connoted by the four terms *brilliancy*, *brilliance*, *intrinsic brilliance*, and *brightness* is broadly the same, and is the emission of light from a surface. I am inclined to drop the simple term brilliance or brilliancy as a scientific unit, just as Blondel dropped *clarté*, and to use *brilliance* only in connexion with *intrinsic brilliance*, which is the emission of light per unit surface. Quantitatively it is the candle-power per square inch or square centimetre. The mathematician who always spies 4π lurking in the background will prefer *lumens* or *milli-lumens* per square centimetre. Neither Blondel, Rosa, nor Carl Hering draw any distinction between brilliancy of emission and brilliancy or brightness due to reflection. L. Weber, on the other hand, has suggested the distinction, and Mr. Harrison follows him. Abney proposed the term *luminosity* for "brightness resulting from illumination," but he uses it in discussing the brightness of different parts of the spectrum, and does not confine it strictly to reflected light. Rosa, in the Paper referred to, does not mention *brilliance* or *intrinsic brilliance*, but deals with *specific radiation* or *flux-density of radiation*. He uses "*brightness*" and "*surface brightness*," both in connexion with a source of light and with the diffuse reflection from an illuminated body, and says that "brightness can refer equally to luminous sources of relatively high specific intensity or to reflecting and radiating sources of low intensities." But a "reflecting source" does not seem to be a good expression. He objects to the use by Blondel and others of e for illumination and radiation, as that gives rise to confusion.

The word "*surface-brightness*," which has been recently introduced in this country, appears to be a literal translation of "*flächenhelle*," and this term seems to be used by Liebenthal both for the brightness of a self-luminous body and for that of an illuminated surface. He says that each element of a glowing body, or, more shortly, each glowing surface-element, has the same *flächenhelle* in all directions,* and in the next paragraph he describes Lambert's observation that a white wall illuminated by the sun appears sensibly equally bright in whatever direction and from whatever distance one looks at it....the *flächenhelle* of an element of the surface is constant at all angles of emission." Lambert in this passage† used *claritas*, a term which he used also for the brightness of a source. He insisted on the distinction between *illuminatio* and *claritas*, but in one or two places refers to *splendor*, apparently for the brightness of a self-luminous body.

Liebenthal seems to use *helligkeit* for the physiological effect on the retina proportional to the *flächenhelle*.

Blondel uses *éclat intrinsèque* for the *intrinsic brilliance* of a self-luminous body as well as for the brightness of an illuminated object, and on page 265 of *The Illuminating Engineer* for April protests against any distinction between the two.

The term *luminosity*, having been defined by a high authority, has taken its place in scientific literature, but illuminating engineering is not quite the same thing as physical science. In electrical science we speak of difference of potential and electromotive force, in electrical engineering we speak of pressure or volts. The British public will probably prefer, and will more readily understand, *brightness* as measured by the new instruments invented by Dow and Mackinney, Edgcumbe and Trezise.

A difficulty in making the distinction recommended by L. Weber and by Harrison and objected to by Blondel is that the intrinsic brilliance or brightness of a translucent shade of opal or

* *Praktische Photometrie*, 77.
† *Photometria*, p. 42.

ground glass or of silk or paper, is due partly to transmission and partly to reflection. The fact that there are two different ways of measuring or of regarding these magnitudes does not make them separate physical quantities. Electricians are familiar with such magnitudes. A foot-pound is a unit of energy; it is also a unit of work; and it is sometimes convenient to regard it as 0·0018 horse-power-second. An ampere may be measured by volts per ohm., watts per volt, or coulombs per second, as is convenient; and we measure watts as volt-amperes, as C^2R, or as joules per second.

The obvious way of measuring intrinsic brilliance is to take the candle-power emitted per unit area. Luminosity, that is, brightness resulting from reflection, may be measured in the same manner, and from one point of view it is, therefore, the same physical quantity as intrinsic brilliance. The alternative to measuring luminosity by candle-power reflected per unit area is to assume a relation between the reflecting power of the substance and that of an ideal perfectly white and perfectly matt or unpolished material. An area of π square feet of such a material receiving an illumination of 1 foot-candle, or an area of 1 square foot receiving a uniform illumination of π foot-candles, reflects 1 candle-power normally, and has a hemispherical candle-power of one-half candle. The experimental difficulty is the illumination of a surface of moderate size to give a measurable candle-power at a distance great enough to comply with the law of inverse squares, say 6 or 8 times the greatest dimensions of the surface. Dr. Sumpner has done this* and has found to what extent various substances and coloured papers fall short of perfect whiteness, or unit albedo, as Lambert and modern astronomers call it. He found that white blotting paper reflected 82 per cent. It might be possible to equal this with white cardboard, but there is likelihood of error due to glaze. Compressed magnesia or barium sulphate has a high albedo and good diffusion, but Dr. Sumpner's careful test of the easily obtained material white blotting paper gives a valuable standard. The British unit of luminosity would be the luminosity of white blotting paper illuminated by 1/0·82, or 1·22 foot-candle. A circle of 1 ft. radius or the projected area of a globe of 1 ft. radius has an area of π sq. ft. A milk-white globe of translucent material of 1 ft. radius, having a light within it, and emitting 1 candle-power in all directions, would be indistinguishable from a reflecting disc of white blotting paper of 1 ft. radius illuminated by 1·22 foot-candle. The intrinsic brilliance of the former would be identical with the luminosity of the latter. It is on this ground that I see no necessity for making a distinction. The luminosity of each would be that of a disc of unit albedo illuminated by 1 foot-candle.

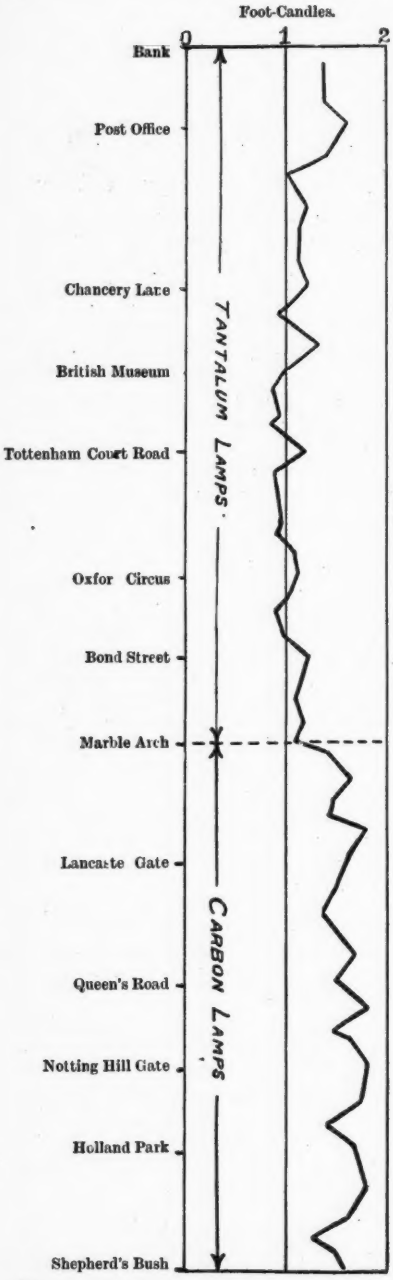
I observe that Blondel considers that intrinsic brilliancy should be measured in the direction of maximum intensity. I am not aware that the intrinsic brilliancy of self-luminous bodies differs at different angles, though this is the case with all diffusively reflecting material that I have examined. I think it is a pity to adopt white blotting paper or any other material as a standard. It is better to determine the absolute albedo, and this may be found with sufficient accuracy for ordinary purposes by assuming Dr. Sumpner's value 0·82, and comparing other materials with it.

Mr. Harrison has used the Whitman sector in exactly the same way and for the same purpose that Whitman did in 1896,* namely, for an investigation into the luminosity of papers coloured with various pigments. This led, two years later,† to the invention of the flicker photometer.

* *Phil. Mag.*, vol. xxxv. 88 (1893) and *The Electrician*, xxx. 381, 411, 439.

* *Physical Review*, iii. 241.

† *Scie ce*, viii. 2 (1898).



Diagrams showing Fluctuation of Illumination during a journey on the Central London Railway, June 14, 1910.

Illumination on Tube Railways.

In his lectures on illumination, to which we have previously referred,* Prof. J. T. Morris gave some interesting figures and diagrams showing the fluctuations which take place in the illumination of the railway carriages on some of the London tube railways. These have since been summarized in *The Architect and Contract Reporter*.

In the example reproduced here the illumination during a journey from the Bank to Shepherd's Bush on the Central London Railway is mapped out. The first part of the journey was taken in a train lighted with tantalum lamps, and the average illumination was 1 foot-candle, but from the Marble Arch onwards, in a carriage lighted by carbon lamps, the average is higher, being 1·6 foot-candles.

It is interesting to notice that the fluctuations are much greater in the latter part of the journey, as would be expected from the fact that carbon filament lamps are more affected by changes of voltage than are metal filament lamps. When the illumination was in the neighbourhood of two foot-candles, the carriage appeared to be well-lighted, and the author concludes that an average illumination of at least 1 foot-candle should be provided. In the following table some data are tabulated regarding the illumination in various London tubes :—

Fluctuation of Illumination in Trains and Trams.

Route.	Type of Lamp.	Illumination in foot-candles.		
		Max.	Min.	Average
Piccadilly Railway	Carbon	1·7	0·55	1·0
Great Northern and City Railway	Tantalum	0·95	0·65	0·8
Central London Railway, East half	Tantalum	1·7	0·85	1·0
Central London Rlwy., West half	Carbon	1·8	1·3	1·6
Metropolitan-District Railway	Carbon	2·0	1·05	1·6
Metropolitan Railway	Carbon	2·6	0·6	1·6
Aldgate to Stratford Tramway	Carbon	1·75	0·28	1·0

* *Illum. Eng.*, London, Vol. III., July, 1910 p. 464.

A Year's Progress in Illuminating Engineering in the United States.

FIVE years have passed since our contemporary *The Illuminating Engineer* of New York came into existence. In accordance with the usual custom of this journal, the first number of the new volume is devoted to a review of the progress during the past year, from which we take a few remarks. Advances in illuminating engineering are still being made and the *rate of progress* seems to be continually increasing. Not only is more work in this field being carried out by experts, but—what is equally gratifying—there is also in evidence a great awakening of interest on the part of the general public.

Among the important events of the past year was the remarkable series of lectures undertaken at the Johns Hopkins University on the success of which we have already commented.

The Illuminating Engineering Society we note has again had a most prosperous session. Its membership during the past year has increased as much as 50 per cent, and a noticeable development has been the growing tendency to pass from agreement on general principles to actual practical applications. In this respect, our contemporary remarks, "the Society henceforth must be a university rather than a preparatory school."

Another striking movement during the past year has been the development of the proposed Association for the Conservation of Vision. This Association, it is suggested, will enlist the support of physicists, engineers, oculists, and physicians; the joint efforts of those interested in the physiological and engineering aspects of illumination respectively will be directed towards the wise application of light and the safeguarding the eyes of the nation. It may also be observed that advances have been made in the organization of fixture manufacturers and in the manufacture of prismatic glassware, especially with a view to artistic effect. It is equally pleasant to note further advances in gas lighting. To quote again from our contemporary, "It is not over stating the situation to say that there has been more genuine progress in gas illumination in this country during the past year than in the four years preceding." Special mention is made of the excellent work of the Illuminating Engineering Laboratory of the Welsbach Company, and the magnificent new show building of the People's Gas Light and Coke Company in Chicago.

Special efforts have also been made to interest architects in illuminating engineering, and in one Western City an illumination club was formed for this purpose. Public lighting likewise steadily develops. The desire for decorative lighting, is spreading, and the value of good illumination in streets is also fully appreciated from the business standpoint. Thus it is remarked "not a single instance has come to our attention where an installation has been discontinued, or any disappointment expressed as to its value."

We may conclude this retrospect by one significant quotation: "The prediction sometimes made that some one particular illuminant is about to displace some one or all of the others will be seen to be entirely groundless. A new illuminant or apparatus for producing light does not supersede, but simply adds to, the general means of securing illumination. Every one of the illuminants at present in commercial use, including the candle and oil lamp, which date back to prehistoric times, down to the most recent discoveries, have found a place in the limitless field of illumination, and are working out their own destiny in accordance with the universal laws of trade and commerce."

The Lighting of the Horniman Museum.

By an Engineering Correspondent.

The Horniman Museum at Forest Hill, although now in the hands of the London County Council, was built and equipped privately by the late Mr. F. J. Horniman, M.P., some eleven years ago. In extent it is not to be expected that this, or indeed *any* suburban or provincial collection, can equal more than a small fraction of one of the national treasure-houses, but nevertheless the exhibits are of an interesting character and attract a considerable number of visitors. From the illuminating engineer's point of view the galleries are certainly instructive.

The present manner of lighting represents the result of sundry experiments undertaken when the building was first erected, various methods and arrangements having been tried but abandoned, owing either to the objectionable reflection of the lights from the glass of the cases or to other causes.

The museum is built on the side of a hill, and consists principally of two large halls round each of which runs a balcony. The first of these halls communicates with the other, which is higher up the side of the hill, by a flight of steps. There are, in addition, several little side corridors and small rooms which are entered from one or other of the large halls and which give access to the cycle-storage room in the basement at one end and open into the gardens at the other. Only a small proportion of the objects could be classed under the seven headings of Art which comprise the Victoria and Albert collection, the greater part having more the nature of those shown at the British Museum in the main building at Bloomsbury, and the natural history section at South Kensington.

The Lower Hall, which is the one first entered, is 120 ft. long by 50 ft. in width and about 40 ft. high. The balcony runs round all four sides of this, at a height of 11 ft., and deep wall-cases are fixed underneath to a height of 7 ft. These wall-cases have "return" ends, projecting 8 or 10 ft. into the room, so that the plan of each side-wall is somewhat like the letter E, but with one or two additional arms. In the bays thus formed other glass cases are placed and many other large ones are arranged down the centre of the hall. The whole is roofed by a white plaster arched ceiling, and light is obtained by large windows on either side of this, but with a wide breadth of plaster in the centre of the arch between the topmost panes, so that though the hall is top-lighted it is not vertically lighted. By day the illumination in the body of the hall is excellent, but, as might be expected, the shade of the balcony darkens the contents of the wall-cases at many points.

At night the bulk of the light is provided by inverted arc-lamps, a line of five of these being suspended along the centre line of the hall at a height of 30 ft. from the floor (*i.e.*, 10 ft. below the ceiling). The direct rays are screened by the metal case of the lamp, as is usual in this method of lighting, and no top reflectors are employed, the light being reflected entirely from the white ceiling.

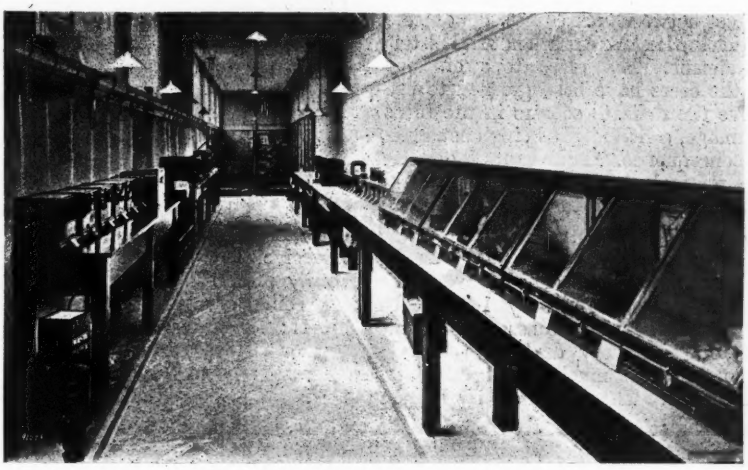
As an adjunct to these in what would otherwise be the darker parts under the balcony, a dozen incandescent pendants are provided, one in each bay and two at each end, 40-watt metallic filament lamps being used at a height of 7 ft. with conical opal shades. It is at times necessary to call these into use during the day if the weather should be dull and gloomy.

The exhibits consist of material intended to illustrate religions, the domestic arts, and the arts of warfare,

and comprise such diverse objects as mediæval armour, musical instruments, idols, barbaric weapons, looms, and other appliances.

Horniman Museum. Balcony in Main Hall.

The character of the light and the whole idea of the arrangement are very good, and the ceiling is an ideal one for inverted lighting except for its great height, but the effect is certainly not equal to daylight. And this is not due to bad design or other defect in the principle on which the scheme has been laid out, but wholly and solely to an insufficient quantity of light. Of course this is also, in reality, a part of the design, but it is a part of which it is not always easy to estimate the exact effect beforehand (wherefore an ample margin in the capacity of wiring is at all times desirable). That the



Horniman Museum. The Aquarium.

authorities should be able very well to afford to increase the candle-power without incurring any charge of extravagance is evident from the fact that the wattage per square foot of floor area at present is only in the neighbourhood of 0·6. It should not be concluded from the foregoing that the light is very bad—merely that it is not perfection. It is, as a matter of fact, far better than that in many a more brilliantly lighted building where shadows, or glare, or general patchiness spoil the effect of the illumination.

The balcony around this hall has cases all round the walls and flat or desk-top cases on the hand-rail. The exhibits are largely ethnological ones of no great size, pre-historic and modern stone-implements, decorative jewellery, or what the less civilized races of the world regard as such, &c. The lighting for these is derived entirely from the five inverted arc-lamps already mentioned, and, at this higher level, is very good.

The Upper Hall is similar to the Lower one in its main features, and has been similarly treated except for the addition of another dozen incandescent lamps. There is somewhat more space between the cases of objects, which are large and small natural history specimens. The glass tops of some of the cases have been greened to preserve the delicate colours in the birds' plumage, a little light being obstructed in consequence. The balcony is devoted to minerals. The remarks on the Lower Hall apply to this one also, the lighting being good but not quite perfect.

There is a small side room on the first floor, some 30 ft. by 18 ft., with side windows. The cases under these windows are very dark in the daytime and are much better seen by lamp-light. The lighting is by 11 incandescent pendants at 8 ft. from the floor.

The corridor below this, devoted to the ever popular, if somewhat gruesome Egyptian mummies, calls for no special remarks.

The continuation of this corridor, alongside the upper hall, has a row of small aquaria and vivaria down either side. Owing to the immensely greater attraction exercised on the human mind, and especially the juvenile human mind, by life and motion than by inanimate nature or art, this is a much patronized portion of the collection. Unfortunately it is by no means the best-lighted one. The corridor is 8 ft. wide and 11 ft. to the ceiling, and the windows are high up on one side wall—6 ft. to the sill, in fact. By night the light is supplied by 17 incandescent pendants, three of these being down the centre of the corridor, 8 ft. up, and the remainder being a row of counterweight pendants along each side. There is a metal screen above some of the tanks, evidently intended to conceal the lamp when this is drawn down low, but, as the number of tanks exceeds that of the points, this could only be done by leaving some of the aquaria unlighted. To avoid this the lamps are pushed up higher and, water being but a poor medium for transmitting light, the animals are not well seen. It is no use trying to economize points in this class of lighting, and one per case is the minimum for satisfactory illumination. If this was provided originally, as seems possible, the lighting has not kept pace with the collection. It should not be difficult or expensive to increase the number, say by means of two flexibles from each ceiling-rose if the wiring admits of this: in any case the three centre corridor lights, which are entirely unnecessary, could be transferred to the sides.

ERRATA.

In the Complete List of Members of the Illuminating Engineering Society (page 353) the following name is to be added:—

Hickman, Dr. H. R. B., M.A., M.B. (Oxon.), M.R.C.S., L.R.C.P., Ophthalmic Surgeon, 5, Harley Street, London, W., and White Hill House, Chesham, Bucks, England.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Annual General Meeting.

(Held at the House of the Royal Society of Arts, London, W., on Tuesday, May 9th, 1911.)

The Annual General Meeting of the Society was held at the House of the Royal Society of Arts, on Tuesday, May 9th, THE PRESIDENT, PROF. S. P. THOMPSON, D.Sc., F.R.S. being in the chair.

The minutes of the last meeting having been read, the HON. SECRETARY proceeded to read out for the second time the names of applicants for membership announced at the last meeting who were now formally declared members of the Society.*

REPORT OF THE COUNCIL.

THE PRESIDENT then called upon the HON. SECRETARY to read the Annual Report of the Council (which will be found in extenso on page 338). While doing so the Hon. Secretary said that it was his pleasureable duty to announce the unanimous decision of the Council to nominate Prof. Thompson an *Honorary Member* in recognition of his distinguished services as President during the first two years of existence of the Society—an announcement which was received with acclamation.

MR. T. E. RITCHIE, in moving that the report be adopted, expressed the view that satisfactory as it was, it verged on excessive moderation. He had many opportunities of ascertaining the views of outside people in regard to the work of the Society, and had often been struck by the way in which its proceedings were discussed up and down the country and in the most unlikely places. He thought that a very great debt of gratitude was owing to the members of the Council. Under the leadership of the President a very great deal of useful work had been done, of which the benefit was yet to come. He had therefore much pleasure in proposing :—"That the Report of the Council for the Session Nov.,1910 to May, 1911 be formally adopted by the Society."

MR. V. H. MACKINNEY seconded the adoption of the report, which he was sure was a source of great pleasure to all the members.

There being no comments upon the report, the PRESIDENT put the motion to the meeting, and it was declared carried unanimously.

THE PRESIDENT then announced the names of several gentlemen who have been invited to act upon the Council for the coming year. He pointed out that according to the Constitution of the Society, the Council, during the first three years, had to arrange for its own membership, and to fill vacancies, or add to its number as occasion might demand. The Council had therefore invited six gentlemen to act in this capacity, the representative nature of the Council being fully maintained in this addition.

THE HON. SECRETARY, in reading the names, said that one or two members still remained to be appointed ; in this way the different sections of the Society would be adequately represented on the Council according to the constitution.

* See *Illum. Eng.*, Lond., May, 1911, p. 289.

VOTE OF THANKS TO THE PRESIDENT.

MR. F. W. GOODENOUGH moved the following resolution :—

"That this meeting, in tendering a very cordial vote of thanks to Prof. S. P. Thompson, D.Sc., F.R.S., as President, for his services, desires to express its appreciation of the privilege enjoyed by the Society in receiving his assistance and support, and of the great benefit derived from his guidance and experience during the first two years of its existence."

He felt sure that the terms of this resolution would commend themselves to all members of the Society, and that they all recognized the very deep debt of gratitude owing to Prof. Thompson ; not only was he an eminent and distinguished head of the Society, but also a most active worker on its behalf. They had in their President a combination of profound scientific knowledge, of businesslike management of affairs, and a courtesy and urbanity, of which it would be difficult to find the equal in any president of any Society. The success of the Illuminating Engineering Society during its initial stages was in a great measure due to Prof. Thompson's constant presence and help.

MR. R. J. WALLIS JONES seconded the vote of thanks to the President. They owed to Prof. Thompson entirely the very sure foundation upon which the Society was now firmly established. Prof. Thompson had not only given them the benefit of his wonderful scientific knowledge, but also, what he personally appreciated so very highly, his guidance in presiding over the excellent discussions which had taken place at the various meetings. Prof. Thompson had a happy knack of getting the best out of all the speakers, and further, he was able, in a very admirable manner, to preserve the balance between the views of speakers representing widely divergent interests. Thus it had been possible to discuss subjects of a somewhat contentious nature, and to secure the best scientific data upon them, without any difficulty whatever. He therefore trusted that Prof. Thompson would realize that they really did feel themselves greatly indebted to him in helping them in the difficult first two years of the Society.

THE PRESIDENT said he desired briefly to thank everybody for their kind expressions towards him, for whatever little service he might have been able to do for the Society during its first two years. It was an honour to him, and would remain an honour, that he had been invited to occupy the presidential chair. The preliminary meetings that were held before the inauguration of the Society had been presided over very ably by Dr. Parsons, and they must not forget the great amount of work in preliminary arrangements and co-ordination that was carried out by a little knot of determined persons, and to them, and in particular to the Hon. Secretary and his associates, the success of the Society was also due.

There had been two years of good hard work. He had felt a little uncertain for a moment or two, about a year ago, whether it was desirable for discussions still to proceed on such very general lines; but the benefit of this had become apparent during the last session, when papers had assumed more specific and more direct, and possibly more practical lines than in the first session. They had first cleared the ground generally, and had since been meeting a few of the many different problems that presented themselves *en bloc*. No doubt they would go on specializing more and more, and would pay less attention to generalities, thus getting down to more direct and technical problems.

Some announcement would possibly be expected that evening as to the name of his successor in the Presidential Chair, but the Council were not in a position yet to disclose that name. The announcement would come in due course, and when they heard it, they would all be gratified. At the same time, whatever name was announced as the actual President of the Society for next session, there would be the satisfaction of knowing that he did not stand alone as a figurehead. He (Prof. Thompson) had not stood alone.

There had been behind him an exceedingly hard working and devoted Council, and an array of Vice-Presidents, of which they might well be proud. With regard to the arrangements for next session, they had got a little further in the way of organization. They had added the name of Dr. Parsons to the list of their Vice-Presidents, and they had taken the step of choosing a Chairman who would preside over meetings of the Society in the absence of the President—a working Chairman in case the President should be prevented from carrying out his work—and he was delighted to be able to inform the meeting that the choice of the Council for a Chairman to act in that way had fallen upon Mr. Goodenough.

There was a matter in the report to which he would like to refer, in reference to his inability to go to Brussels to represent the Society last Autumn. Considerations of health obliged him to remain longer in mid-Europe than he had intended originally, and consequently he could not be in South Europe and North Europe at the same moment.

There was also one paragraph in the report which he was sure would be read with regret. This was the mention of the names of two of their distinguished members who had recently passed away, both of them personal friends of his. Dr. Corsepius, of Cologne he had known for a good many years as an electrical engineer, an extremely capable man, and one for whom he had a great personal regard. The other name—and it was interesting that these two names represented the two chief wings, the two balancing sides of the Society—was that of Mr. Colson, the gas and municipal engineer at Leicester. He also was an intimate friend. Mr. Colson was a splendid organizer and a wonderful worker; a man of great force of character, and whose presence was widely known and valued. The Society had suffered a distinct loss in losing such men from its membership.

Continuing, the President referred to the address which he delivered at the opening of the first session, in which he sketched out a number of matters which he thought might enter into the scope of the Society in the future. He recalled that he mentioned a number of outstanding or half-solved problems, and that his friend Mr. Trotter had poked a little fun at him by the remark that the various statements as to the problems to be solved had been prefaced by the query "Does anybody know whether." As a matter of fact, he said, they had been discussing some of these things about which, a year and a half ago, there was very little information available. He was sorry that he had not been able to be present at the meeting when Mr. Waldram's paper on the effect of wall papers and the absorption of light by dull surfaces had been read, as it was one of those things upon which he expressed his ignorance. All of them now knew a little more than they did upon this subject 18 months ago, and he mentioned that merely as one example of a great many questions which had been discussed, in which they had made distinct progress.

Again, the two discussions on Library Lighting and School Lighting, furnished a basis for a great deal of future work. They now had, partly due to the energy of their Hon. Secretary and his assistant, Mr. Dow, definite statistical matter about rooms used as library rooms, and rooms used as school rooms; information which they had not to anything like the same extent before. If the Society had done nothing else than publish these figures, he considered it had justified its existence. But there was much work to be done, and from the Council's report, it would be seen that there was enough matter before them for discussion without end. But they were not standing still. There was going to be a magnificent Coronation soon, and it was a very interesting question as to how the illuminating engineer would come into action in the case of the Coronation. In the field of decorative lighting much remained to be learned. He ventured to think that among the most magnificent examples of illumination made during the festivities of the Coronation, there would be many accomplished mainly by violating

rules that they had been laying down for the general illumination of public buildings. They would have some installations in which glare was a bad feature and in which sources of light were mis-placed; there would be extraordinary displays of unnecessary amounts of light for the purpose of producing what was ordinarily called illumination. But even out of exaggeration, out of glare, and out of sudden displays, the illuminating engineer would be able to gather useful thoughts. He would be able to pursue his studies actually in the midst of the most dazzling coruscations of light, and it might be that the Society would afterwards have a paper by some member who had found it advisable to make a study of these extraordinary effects.

There had been progress in yet another direction. He thought it might have been an impossible thing eighteen months ago, when the Society was founded, for a serious project to be laid before a London municipality for public lighting, jointly by means of electricity and gas. Quite apart from the merits of the scheme, he welcomed it as a remarkable concerted effort. In this respect it was a very great step in advance indeed, and an excellent illustration of the work of the Society in uniting the interests of those connected with different branches of lighting, so as to enable them to work together with a common end in view.

The Illuminating Engineering Society was really still only in its initial stages. Two years was nothing in the life of a Society. Institutions went on. Individuals might come and go, their places were filled by others, but the work of a society was carried on; and he ventured to repeat the conviction already expressed by one of the speakers that evening, that the benefit of the work during the past two years of the Illuminating Engineering Society was largely yet to come, and largely yet to be recognized. It was work which had been done with good will, and with knowledge and purpose, and it would survive and be an advantage in the future. He thanked the members for the motion which they had passed, and when he quitted the Chair in the autumn, he would feel that he was leaving it at the moment when the progress of the Society was in full blast, when the work was being eagerly carried on, and when the membership of the Council, as well as the membership generally, had its interests thoroughly at heart, and were fully competent to carry it forward.

Vote of thanks to Council and Officers.

Mr. A. P. Trotter then moved "that this meeting extends a cordial vote of thanks to the Council and officers for their efforts on behalf of the Society during the past session."

He said it was probably only those on the Council who could fully appreciate the labour which the work of the Society involved. The responsibility of members of the Council of scientific societies generally were great, but the responsibilities of those who founded a new Society were of a different character. Two years ago, doubt was expressed by some people whether there was enough work for the Society to do, and whether their interests would not conflict with those of existing societies. During these two years, the unseen labours of the Council and officers had borne their fruit.

The choice of members of the Council must have been a serious matter, in view of the necessity for balancing the various interests, but it had been admirably carried out. Although the interests of different sections of the membership had been different, there had been no conflict between them. There had been co-operation, and many of them had made new acquaintances through the Society. The work during the year had been very varied; it was almost impossible to predict the direction in which they were going, but the outlook for the future was very hopeful. He shared Prof. Thompson's gratification that they had passed on to more detailed subjects. In conclusion, Mr. Trotter expressed the hope that next session it would be found possible to keep the authors sufficiently up-to-date to enable copies of their papers to be distributed beforehand, in

order that they might be more thoroughly discussed at the meetings.

MR. W. R. RAWLINGS seconded the vote of thanks, and speaking as an electrical contractor, expressed himself in appreciative terms regarding the benefit which he had derived from membership in the Society. He admired the manner in which the affairs of the Society had been conducted, laying special stress on the great benefit of being able to publish its Transactions in *The Illuminating Engineer*, and concluding by a complimentary reference to the work of the Hon. Secretary.

This vote of thanks was accordingly put to the meeting and declared carried unanimously, and MR. L. GASTER (*Hon. Sec.*) briefly returned thanks on behalf of the Council and officers of the Society, remarking that the hard work of the past two years had been rendered pleasant by the appreciation it had received and by the harmonious way in which all had exerted themselves for the welfare of the movement. He thanked those present for the cordial way in which they had referred to his own services, and he in turn wished to acknowledge the great help he had received from his assistant, Mr. J. S. Dow.

MR. HAYDN T. HARRISON then briefly moved "that this meeting extends a cordial vote of thanks to the Hon. Auditors of the Society for their services, and that these gentlemen be requested to act in this capacity for another year." This resolution was seconded by MR. CHARLES W. HASTINGS and declared carried unanimously, and THE PRESIDENT then rose to propose a vote of thanks to the Royal Society of Arts.

VOTE OF THANKS TO THE ROYAL SOCIETY OF ARTS.

THE PRESIDENT, in expressing the indebtedness of the Society for the granting of permission for meetings to take place in the House of the Royal Society of Arts, referred to the early history of this old-established Society, which, many years ago, had already taken an interest in questions connected with illumination and had arranged for the exhibition of gas and electric lighting in their initial developments. It was therefore most fitting that this room, which had been the scene of so many exhibitions of historic interest should now be devoted to the meetings of the Illuminating Engineering Society, and it had been most gratifying to enjoy this privilege and to receive the support of the Royal Society of Arts.

He had therefore pleasure in proposing the resolution:—"That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of the rooms during the past session, and to record its appreciation of its encouragement and support."

PROF. A. G. VERNON HARCOURT, in seconding the resolution, also recalled the many papers and lectures dealing with illumination and with the eye, which he had heard in this room and corroborated the President's reference to the keen interest taken by the Royal Society of Arts in these subjects. MR. J. DARCH also supported the motion, which was then carried with acclamation.

THE PRESIDENT, in closing the proceedings, announced that the Council had that day nominated two committees to carry on some of the work which has resulted from the discussions during the past session. One committee will deal with school lighting, and another with library lighting, and he expressed the hope that in the autumn, some of the deliberations of these committees would be placed before the Society.

He also desired to draw attention to the suggestive list of subjects on which papers were invited for the next session* and the Council hoped that members would bear this in mind and send in some interesting contributions during the vacation.

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* See p. 345.

Report of the Council for the Session Nov., 1910 - May, 1911.

This report—the third issued by the Council since the inception of the Society—marks the termination of its second session. There should be little need to dwell now upon the objects of the Illuminating Engineering Society; the events of the first two sessions have doubtless served to show the useful work which is being done, and there are already apparent possibilities of even more important practical tasks confronting the Society in the near future.

During the past session the value of the impartial and international platform afforded by the Society has been freely acknowledged. Several important subjects have been dealt with, and have aroused the interest of other Societies and Associations who sent representatives to join in these meetings. It may be added that the Society experienced no difficulty in finding subjects for discussion; the problem has again been how to deal adequately with the subjects broached in the time available, and on two occasions it was found absolutely essential to adjourn the discussion, and to devote to it a second evening.

Growth of Interest in Illuminating Engineering.

The development of general interest in illumination, which was commented upon in the two previous reports, is still proceeding. Not only are there many more articles on the subject in the technical press, but the variety of societies and associations which now devote special attention to one or other aspects of illuminating engineering is very striking. Among those which have been prominent in this respect we may mention the Institutions of Gas and Electrical Engineers, the Royal Sanitary Institute, the Royal Photographic Society, Institution of Sanitary Engineers, the Optical Society, the Junior Institution of Engineers, &c.

Special acknowledgment should also be made of the assistance that has been rendered to the Society's work by the press. Both in technical journals and in the daily Press its meetings have been the subject of frequent reference. Each aspect of illumination in turn taken up by the Society has proved to be of keen interest to some section of the public. The Illuminating Engineering Society thus seems destined to supply a much needed link between those interested primarily in the technical and engineering aspects of illumination and the consumer.

It may, perhaps, be questioned whether any technical society has ever stood in quite the same fortunate position in this respect.

Education in Illuminating Engineering now desired.

There are, however, certain aspects of illumination which have attracted special attention during the past year. The electrical and gas industries alike have been considering the best means of interesting the general public in lighting matters, and have organized campaigns with this object. At the same time there is a rising demand for better educational facilities in the subject. A notable step was recently taken by the Johns Hopkins University (Baltimore, U.S.A.)* in organizing a special post-graduate course of thirty-six lectures in illuminating engineering, delivered by eminent authorities in their respective fields. In this country a movement is on foot for the organization of courses of instruction in various technical colleges and institutes. A course of lectures of this kind recently took place at the Westminster

* *Illum. Eng.*, Lond., vol. iii., 1910, pp. 417, 447, 669.

Technical Institute* in which the various illuminants were dealt with in turn, and such questions as street, school, and factory lighting received attention. The Education Committee of the London County Council have also recommended the erection of a central Opto-Technical Institute† in whose scope of work, it is hoped, such matters as the effects of light on sight, the design of photometric apparatus, &c., will be included.

Industrial Lighting.

Among other questions that have been brought prominently forward may be mentioned industrial lighting.

The necessity for more precise recommendations on the subject of factory and industrial lighting has also been pointed out in influential quarters. The Report of H.M. Chief Inspector of Factories for 1909‡ dealt with the subject even more fully than in the past. A special section was devoted to a summary of the present position, and, in referring to the available sources of information on the subject, special acknowledgment was made of assistance derived from the official organ of the Society. Summing up the vital importance of good lighting in factories the Report remarks :—

"The importance of adequate lighting in industrial employment is obvious : as a matter of safety, especially where dangerous processes are carried on ; as bearing upon health in many ways, directly and indirectly ; and as a condition of efficient work. On the health side it is hardly necessary to point out that inefficient illumination entails risk, strain, and ultimate damage to the sight, even apart from the interference with work, or that it tends to neglect of cleanliness and adds to the risk of working in poisonous materials."

The Report also lays stress on the desirability of collecting further data on the subject, and provision is being made to secure the needed information.

The question of industrial lighting also assumed a prominent place in the deliberations of the Second Congrès International des Maladies Professionnelles, held in Brussels during September, 1910,* under the patronage of the Belgian Government. A number of important papers were presented dealing with various aspects of the subject, and the question of providing adequate illumination in the case of dangerous machinery was mentioned as a matter of special moment.

This last question has also been the subject of special comment in the Report just issued by the Departmental Committee on Accidents in Factories.† Statements by representatives of the Society of Iron Founders, the Brass Workers Society, and by other witnesses are quoted to the effect that inadequate illumination has been a frequent ground for complaint. Several inspectors make the same remark, adding that "inadequate lighting is a very frequent cause of accident and of grave danger."

This matter of factory and industrial lighting has been singled out by the Council for special comment, since it appears to illustrate, in an exceptionally happy manner, the way in which the international and impartial influence of the Society is making itself felt.

Membership and Support.

During the past session the influence and membership of the Society have made steady progress. The number of members now exceeds 270, and it is equally gratifying to note that the Society continues to attract the support of many eminent authorities in various parts of the world. The membership is still of an extremely representative character, the various sections being substantially the same as last year and proportionately distributed as follows :

* *Illum. Eng.*, Lond., Feb., 1911, p. 111 ; March, 1911, p. 180.

† *Illum Eng.*, Lond., vol. iii., 1910, p, 643, 674.

‡ *Illum. Eng.*, Lond., vol. iii., 1910, p. 493.

* *Illum. Eng.*, Lond., vol. iii., 1910, p. 599.

† *Illum. Eng.*, Lond., March, 1911, p. 193.

	Per cent.
Electrical Engineers and members concerned mainly with Electric Lighting	35
Gas Engineers, Manufacturers of Gas Appliances, &c.	20
Professors of Physics and Engineering, Experts in Photometry, &c.	13
Representatives of Oil, Acetylene, Petrol Air Gas Lighting, &c. ..	7
Physicians, Oculists, Opticians, &c.	10
Architects, Surveyors, &c. ..	3
Miscellaneous, including makers of Shades and Reflectors, Mechanical Engineers, and others not exclusively connected with any one system of lighting	12
	100

The maintenance of this diverse membership and the absence of undue preponderance of any one element is very satisfactory. There is, however, one section which it is still desired to see more fully represented, namely, the architectural and allied professions.

In accordance with the Constitution of the Society* the Council are empowered to nominate each year not more than three Honorary Life Members of the Society; it will be recalled that during the first year Sir Wm. Preece, K.C.B., F.R.S., Sir Joseph Swan, M.A., D.Sc., F.R.S., and Prof. A. G. Vernon Harcourt, M.A., F.R.S., were approached and kindly consented to become the first three Honorary Members. During the present year it has been most gratifying to the Council to add to this list the name of Dr. A. Moeller, President of the Académie Royale de Médecine and Member of the Commission des Accidents du Travail, &c., the distinguished President of the Second Congrès International des Maladies Professionnelles. Another name has also been added to the list of Vice-Presidents—that of Prof. Dr. W. Wedding, of Charlottenburg, whose world-wide reputation as an authority on matters connected with illumination is known to all members of the Society.

* *Illum. Eng.*, Lond., June, 1909, pp. 377, 378, articles 5, 18, and 24.

The Council also desire to express their appreciation of the great privilege enjoyed by the Society in having Prof. Sylvanus Thompson as President during the first two Sessions; in spite of the many calls upon his time, the President has devoted himself to the work of the Society, which, in its initial stages, has derived the very greatest benefit from his ripe judgment and experience.

It is with deep regret that the Council record the death of two valued members of the Society—Dr. M. Corsepius of Cologne and Mr. A. Colson of Leicester. Dr. Corsepius had acquired a deservedly high reputation by his researches on photometry, and up to the last had taken an active interest in the work of the Society. Mr. Colson, as Chief Engineer and Manager of the Leicester Gas and Electricity Department, had won the esteem of representatives of both systems of lighting, and his death was felt to be a great loss to the Society.

Meetings of the Society during the Past Year.

During the past session seven meetings (not including the Annual General Meeting) have been held. At the opening meeting a valuable paper, summarising 'Recent Progress in Gas Lighting,' was delivered by Mr. F. W. Goodenough* on November 8th, 1910. This was followed by a corresponding paper by Prof. E. W. Marchant† dealing with 'Recent Progress in Electric Lighting.'

Having thus dealt with the two chief methods of illumination the Society proceeded to discuss practical applications. On January 16th a discussion on Library Lighting‡ was opened by Mr. L. Stanley Jast (*Honorary Secretary of the Library Association and Chief Librarian of the Croydon Borough Libraries*) and Mr. J. Duff Brown (*Chief Librarian, Islington Public Libraries*), followed by a paper by Mr. J. Darch, F.S.I.

On this occasion the valued co-operation of the Library Association was

* *Illum. Eng.*, Lond., Dec., 1910, p. 715.
† *Illum. Eng.*, Lond., Jan., 1911, p. 29.
‡ *Illum. Eng.*, Lond., Feb., 1911, pp. 83–92.

invited, and the discussion on the evening of January 16th was given up mainly to the standpoint of the librarian. A general invitation to be present was given to all members of the Library Association, many of whom took part in the discussion. It having become evident that a second meeting would be necessary in order to do justice to the subject, the discussion was resumed on January 31st.* On this occasion the standpoint of the lighting expert and the contractor received most attention. A special feature of the proceedings was the presentation of the results of actual measurements of the illumination in a large number of London libraries carried out by the kind permission of the librarians concerned. These papers gave rise to a most fruitful discussion, and presented a striking example of the benefit of co-operation between the various bodies interested when dealing with a subject of mutual interest.

The precedent set on this occasion was again followed at the next meeting of the Society, on February 16th,† when two papers, dealing respectively with the Natural and Artificial Lighting of Schools, were presented by DR. J. KERR, *Medical (Education) Officer to the London County Council*, and DR. N. BISHOP HARMAN, *Lecturer in Ophthalmology, West London Post Graduate College, Oculist London County Council Education Department*. On this occasion the Association of Medical Officers of Schools, the Association of Technical Institutions, the Association of Teachers in Technical Institutions, and the London Teachers' Association, were all invited by the Society to send delegates to the meeting, and representatives of these bodies participated in the discussion. The first evening's discussion was devoted mainly to the standpoints of the medical and scholastic professions, and the more purely engineering aspects were discussed in a second meeting on March 14th. The results of a series of measurements of the actual conditions of illumination in various L.C.C. Schools, Public Schools, and Colleges were also presented.

* *Illum. Eng.*, Lond., March, 1911, p. 142.
† *Illum. Eng.*, Lond., March, 1911, pp. 154-165.

At the final meeting, on April 24th,* two papers were read by MR. HAYDN T. HARRISON, M.I.E.E., and MR. P. J. WALDRAM, F.S.I., dealing with 'The Ratio of Light to Illumination' and 'Some Notes on the Effect of Wall Papers upon the Illumination of Interiors.'

Proposals were made by the authors of these papers that Joint Committees should be formed to consider the framing of simple recommendations on the subject of School and Library Lighting, and the effect of wall papers in Interiors: this suggestion will receive the careful consideration of the Council.

It will be observed that the papers presented during the course of the session covered a very wide field, and that the Society in the last session has followed the plan of proceeding from general principles to practical applications of illuminating engineering. A point to be noted is that each discussion brought to light matters on which further information was desired, so that, should the Society at some future time revert to these subjects again, it may be anticipated that ample new material for discussion will be available. A word of thanks on behalf of the Society is due to the authors of these papers, which invariably gave rise to interesting discussions.

INTERNATIONAL ATTITUDE OF THE SOCIETY AND CO-OPERATION WITH OTHER BODIES.

The above brief account of the papers read during the Session may serve to show the methods of co-operation being pursued by the Society. It is hoped that, as the practical applications of illuminating engineering continue to receive a fuller share of attention, many matters will be discussed which are of considerable interest to other outside bodies.

Acknowledgment should next be made of the great benefit derived by the Society from the assistance of its many Corresponding Members in these discussions.

The interest attaching to the discussions on School and Library Lighting, for example, was largely augmented

* *Illum. Eng.*, Lond., May, 1911, pp. 280-289.

by the presentation of such communications, and the proceedings of the Society have been followed with keen interest by its representatives in foreign lands. This international connexion is of great value in promoting the interchange of views on illuminating engineering among the greatest authorities in different countries, and should do much to pave the way for international agreement in the future on such questions as the nomenclature and terminology of illuminating engineering.

As explained in the Report for 1909–1910, it is the special desire of the Society to assist and take part in International Congresses and gatherings at which matters of interest connected with illumination are discussed, and which provide opportunities of arousing interest in these questions. A valuable precedent in this respect is supplied by the Second Congrès International des Maladies Professionnelles which was held in Brussels in September, 1910. The Congress was attended by representatives of the Governments of various nations. Many of those participating were authorities of world-wide reputation in their respective departments. It was therefore very gratifying to find that the subject of industrial illumination was allotted a prominent position in connexion with industrial hygiene, and the Council gladly availed themselves of the invitation to send delegates to the Congress. Originally four delegates, namely, Prof. S. P. Thompson (President), Mr. L. Gaster (Hon. Secretary), Mr. R. J. Wallis Jones, and Mr. J. Eck, were nominated, but Prof. Thompson and Mr. Wallis Jones were unavoidably detained at the last moment, and the Society was therefore represented by Mr. Gaster and Mr. Eck. The former presented a paper on the 'Hygienic Aspects of Illumination,' and valuable contributions dealing with various aspects of the subject were also presented by Dr. A. Broca, M. F. Massarelli, Dr. F. Terrien, and others.*

It may confidently be predicted that the efforts of the Society in this direction will bear good fruit in the future, and its work has already received the stamp of approval in various influential quarters. Following participation in this Congress, the Society was privileged to secure the valued support of the President, Dr. A. Moeller, as an Honorary Member, and also to enrol among its Corresponding Members Dr. A. Broca (Paris), Dr. L. Carozzi (Milan), and Prof. L. P. K. Langlois (Paris), all of whom have taken a special interest in the physiological and hygienic aspects of illumination.

Invitations to participate in the Annual Congress of the Royal Sanitary Institute and the Dresden Exhibition of Hygiene, to be held from May to October during this year, have also been received by the Council, which is considering the best means of giving effect to the interest of this Society in these gatherings. Meantime members who desire to take part are invited to communicate with the Hon. Secretary, Mr. L. Gaster, on the subject.

In referring to the international expression of interest in illuminating engineering, a word or two may be said as to the progress of the Illuminating Engineering Society in the United States. The expectations of the continued prosperity of the movement originated in that country have been completely fulfilled, and, in the light of this experience, we have every reason to hope for similar sustained prosperity.

During the past year the membership of the *American Illuminating Engineering Society* (which at a corresponding period last year already exceeded 1,000) has increased by over 50 per cent. The Society is now said to include among its supporters practically every well-known authority on lighting matters in the United States. A feature of the movement has been the logical passing of discussion to the more practical application of illuminating engineers, agreement on many general principles being now secured. There has also been a marked growth of interest on the part of the non-technical public.

* *Illum. Eng.*, Lond., vol. iii., 1910, p. 593.

At the same time scientific matters have not been neglected. The question of the nomenclature of quantities used in illuminating engineering has been considered by a sub-committee appointed in the United States for the purpose,* which has issued a tentative list of terms and definitions. It is hoped that these may shortly be the subject of international discussion, and the wish has been expressed that the Society in this country should join hands in securing common agreement on such matters. This suggestion, it need not be said, is welcomed, and will be borne in mind by our Society when the question is ripe for international consideration.

In addition to these evidences of prosperity it may be added that the American Society has apparently experienced not the least difficulty in finding subjects for discussion; the high standard of its earlier meetings has been fully maintained, and the Annual Convention was again productive of a series of valuable contributions. The unique Course of Lectures at the Johns Hopkins University has already been mentioned. This took place immediately after the Convention in Baltimore, and is justly regarded as setting a valuable precedent as regards instruction in illuminating engineering.

Financial Position of the Society.

The Balance Sheet showing the income and expenditure of the Society up to the end of the year 1910 is appended. The Society is fortunate in having been able, in spite of its present limited membership and very reasonable subscription, to carry out so much work.

That it has been found possible to do so, and yet to keep the expenditure within bounds, is mainly due to the very satisfactory arrangement made with the Illuminating Engineering Publishing Co., Ltd., that *The Illuminating Engineer* published in London should be the official organ of the Society. It is estimated that, had it been necessary to publish and circulate the transactions in the ordinary way, the cost to the Society would probably have exceeded £300 a year, a sum which naturally could not have been afforded by the Society with its present membership and subscription. The established international connexion and circulation of the journal has been of considerable benefit to the Society in spreading a knowledge of its work and giving the widest publicity to its proceedings. The large amount of attention which the doings of the Society have received has been largely owing to this fortunate arrangement. The fact that the *Illuminating Engineer* is a monthly journal has also been much appreciated by the members, since it has enabled the prompt publication of papers read and discussions after they have taken place, and has furnished a convenient means of announcing forthcoming events.

The Society has also been exceptionally fortunate in not having been called upon to meet many customary expenses such as rent for offices, Secretary's salary, &c., and a debt of gratitude is due to its officers who, in an honorary capacity, have ungrudgingly devoted much time to its affairs.

The Standard Specification for Street Lighting.

It will be recalled that at a meeting of the Society on December 9th the President announced that the Council had appointed a committee to consider the best steps to be taken in framing a Draft Standard Specification for Street Lighting, and letters were subsequently sent to the Institutions of Gas and Electrical Engineers inviting co-operation on this matter.

Subsequently the Council were informed that the Institution of Electrical Engineers were also considering the formation of a joint Committee on which the Institutions of Gas and Electrical Engineers, the Illuminating Engineering Society, and the Association of Municipal and County Engineers were invited to be represented. A letter from the Institution of Electrical Engineers was received desiring that the Illuminating Engineering Society should appoint several gentlemen to act as delegates.

* *Illum. Eng.*, Lond., Feb., 1911, p. 74.

At a Council meeting on March 14th it was resolved to accept this invitation, and five representatives of the Illuminating Engineering Society were appointed. It is also interesting to observe that a considerable number of the delegates acting on this joint Committee are members of our Society.

In requesting these gentlemen to act as delegates, it was pointed out that the action of the Society in being represented on this occasion should not prejudice its opportunities of future independent action, more especially as the priority in forming a committee to deal with the matter rested with our Society, and because the international and impartial attitude of the Illuminating Engineering Society marked it out as specially fitted to undertake this work.

Meetings of the Joint Committee are proceeding with a view to arriving at some common ground of agreement before drawing up a tentative form of specification.

It is conceded that the adoption, even tentatively, of a Street Lighting Specification such as would meet with common acceptance would be of considerable benefit in forming a basis of agreement as to what constitutes good street lighting.

Whatever be the upshot, however, the mere fact of it being possible for representatives of different systems of lighting and others interested to meet together with a view to co-operation for their mutual advantage is no small thing; it is also surely a striking testimony to the growth of the spirit of toleration which the Illuminating Engineering Society desires to see established.

Future Work and Outlook for the Next Session.

In conclusion it need only be said that the prospects of the Society are even brighter than at the conclusion of the Society's first year of existence, and that the past Session has again been of a most encouraging character. In the first session the discussions dealt mainly with principles; in the second it has been found possible to deal in greater detail with practical applications. There are now facing us many important practical problems to be solved, and many outlets for the possibilities of valuable service, and there seems less reason than ever to anticipate any difficulty in finding ample material for discussion.

The Council is now considering the programme of papers for the next session, and contributions will be welcome. The list of subjects published in the attached appendix for their guidance in this respect, although only suggestive, will serve to show the variety of matter available.

Besides inviting the assistance of members in this direction, the Council, while conscious of the generous support so far received, desire again to impress upon members the importance of allowing no opportunity to pass of interesting others in the work of the Society, so that the steady progress in prestige and numerical strength may be sustained during the vacation and the new session entered upon with every prospect of enduring success.

By Order of the Council,

Leon Gaster, Hon. Secretary.

ERRATA.

Prof. A. Blondel points out that in his 'Note on Illuminating Engineering Nomenclature' which appeared in our last number (p. 265), the term cos β was omitted from the denominators of the three formulæ for intrinsic brilliancy. These should appear as follows:

(1) $$\frac{1}{10{,}000 \times \pi}$$

(2) $$\frac{1-a}{10{,}000 \times \pi}$$

(3) $$\frac{(1-a)}{10{,}000} \cdot \frac{f(\beta)}{\pi \cos \beta}$$

He also suggests that the word "apparent" should be inserted in front of "intrinsic brilliancy," so that the general formula (No. 3) would be for *apparent intrinsic brilliancy.*

APPENDIX I.

Papers Invited for the Next Session.

The Council take this occasion of inviting papers for the next Session, which will open in November of this year, and the following list of subjects has been prepared for the guidance of members in this respect. All communications on the subject should be sent to the HON. SECRETARY (Mr. L. Gaster, 32, Victoria Street, London, S.W.), from whom further particulars can be obtained.

Naturally the list is intended to be *suggestive* only and by no means exhaustive, and the Council will welcome contributions on other allied subjects connected with illuminating engineering of interest to the Society :

1. New developments and novel applications of gas and electric lighting.
2. General progress in (*a*) acetylene lighting, (*b*) incandescent, oil, paraffin, and petrol air lighting.
3. The nomenclature and terminology of illuminating engineering.
4. New forms of instruments for measuring light and illumination and new apparatus for use in the photometrical laboratory. Methods of testing colour. Methods of testing the steadiness of sources of light.
5. The design and functions of shades and reflectors and their value in interior and outdoor lighting.
6. Fixture design : the compromise between artistic and illuminating principles.
7. The measurement of daylight and its application by the architect to designing window-space, and the access of natural light to interiors. The value of photometry in deciding ancient light cases.
8. Private house lighting.
9. What constitutes good street lighting ?
10. Decorative lighting and illuminating engineering from the standpoint of artistic effect and architectural principles.
11. Simple methods of calculating beforehand the distribution and intensity of illumination in interiors.
12. Instruction in illuminating engineering : Courses of lectures and laboratory work, &c.
13. The benefits of good illumination from the insurance standpoint, and as a means of preventing accidents.
14. The value of good illumination in factories and workshops from the hygienic and sanitary standpoint.
15. Portable safety lamps for mines, &c.
16. Modern methods of lighting and illuminants employed in lighthouses, buoys, coast-lights, beacons, &c.
17. The use of light for advertising purposes, illuminated signs and devices, illuminated placards, billboards, notices, &c.
18. The production of coloured light, and the best means of modifying the spectra of artificial illuminants so as to resemble that of daylight.
19. Problems encountered in the lighting of museums, picture galleries, &c.
20. The decorative lighting of parks, avenues, and flower gardens, fêtes, &c.
21. The illumination of railways, tramcars, platforms, carriages, tubes, and underground railways, &c.
22. The physiological aspects of illumination, and the effects of artificial light on the eyes.
23. The design of headlights for trains and motor vehicles. The correct application of light in projection, searchlights, lanterns, cinematographs, &c.
24. The relative advantages of direct and indirect illumination, the best means of combining the systems, and the occasions on which either method, or a combination of both, is most suitable.
25. The illumination of shop interiors and show windows.
26. The artificial illumination of athletic grounds, tennis courts, skating rinks, bowling alleys, &c.
27. Country house lighting by private electrical installations, by acetylene, or by petrol air and incandescent oil.
28. Theatre lighting : illumination on the stage and its use to produce scenic effects, &c.

APPENDIX II.

Illuminating Engineering Society.

(Founded in London, 1909.)

STATEMENT OF INCOME AND EXPENDITURE FROM JUNE 30TH, 1909, TO DECEMBER 31ST, 1910.

Dr. EXPENDITURE.	£ s. d.	£ s. d.	*Cr.* INCOME.	£ s. d.	£ s. d.
To Expenses of Meetings, including Rent of Hall, Refreshments, and Porters', Lantern Operator's, and Shorthand Reporter's Fees, for eight meetings	40 13 0		By Subscriptions received for the period ending December 31st, 1910 ...	141 9 9	
To Postage and Sundries	13 17 0		By Subscriptions part paid for 1911 ...	4 9 3	
To Clerical Work	12 0 0				145 19 0
	66 10 0		By Outstanding Subscriptions, &c. ...		24 3 0
To Illuminating Engineering Publishing Co., on Account for Members' Subscriptions to Journal ...	58 5 6				
To Illuminating Engineering Publishing Co., amount due in contra ...	3 19 0				
To Bank Charges for cheque book ...	2 6				
		128 17 0			
		41 5 0			
		£170 2 0			£170 2 0

BALANCE SHEET FROM JUNE 30TH, 1909, TO DECEMBER 31ST, 1910.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
To Sundry Creditors— General Printing, Stationery, Invitation Cards to Meetings, Advance Proofs, Reprints of Papers, Annual Reports, Lists of Members, &c.	30 0 0		By Cash at Bank	17 2 0	
To Subscriptions paid in advance ...	4 9 3		By Outstanding Subscriptions	24 3 0	
To Illuminating Engineering Publishing Co., in respect of Subscriptions	8 13 0				41 5 0
		43 2 3	By Balance		1 17 3
					£43 2 3

Accounts examined and found correct.

A. DENMAN JONES
V. H. MACKINNEY } *Hon. Auditors.*

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909).

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(*May*, 1911.)

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	Taylor, H. J.	Electrical Engineer, 63, Queen Victoria Street, LONDON, S.W.
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	Topley, W. W. *Mem. Inst. Gas Engrs.*	Secretary of the Croydon Gas Co., Katherine Street, CROYDON, England.
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	Trotter, A. P. *M.I.E.E.*	Electrical Adviser to the Board of Trade, 8, Richmond Terrace, Whitehall, LONDON, S.W.
V.P., C.M.	**Ubbelohde, Prof.**	Gen. Secretary of the International Petroleum Commission, KARLSRUHE, Germany.
V.P., C. M.	**Ulbricht, Prof.**	President of the Königl. Generaldirektion der Sächsischen Staatsbahnen, Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker, Hettner Str. 3, DRESDEN.
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	Walmesley, Prof. R. M. *D.S.C., F.R.S.E.*	Principal of the Northampton Institute, 28, St. John Street, LONDON, E.C.
	Walters, H.	Engineer to the G.P.O., 9A, King Edward Street, LONDON, E.C.
	Watkins, S. S. A.	Demonstrator in Optics and Electrical Engineering at the Central Technical College, Exhibition Road, LONDON, S.W.
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V.P.	**Wedding, Prof. Dr. W.**	Professor at the Technische Hochschule, Charlottenburg, Gross Lichterfelde, Wilhelmstrasse, 2, BERLIN.
	Weekes, R. W. *M.I.E.E.*	Consulting Engineer, Maxwell House, Arundel Street, Strand, LONDON, W.C.
C.M.	Weinbeer, E. W.	Electrical Engineer and Professor of Electrotechnics at Charlottenburg, 4 Röntgenstr, CHARLOTTENBURG, Germany.
	Weston, G. C. *A.M.I.E.E.*	Distribution Engineer to Kensington and Knightsbridge Electric Lighting Co., Prince Consort Road, South Kensington, LONDON, W.
	Wheat, H. C.	Electrical Engineer, 9, Moat Street, RUGBY.
	Wild, L. *M.I.E.E.*	Director of the Westminster Electrical Testing Laboratory, York Mansions, York Street, LONDON, S.W.
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	Williams, J.	General Manager of the Foreign and Colonial Lighting Co., Ltd., Emberton Lodge, NEWPORT PAGNELL, England.
	Williams, W. H. *A.M.I.E.E.*	Manager of Lamp Dept. of the Electrical Co., 3, Onslow Avenue Mansions, RICHMOND, Surrey, England.
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	Wilson, D. R.	H.M. Inspector of Factories, Home Office, Whitehall, LONDON, S.W.
	Wohlauer, A. A.	Consulting Electrical Engineer and Lighting and Heating Expert, 546, Fifth Avenue, NEW YORK, U.S.A.
V.P.	**Wood, Sir Henry Trueman.**	Secretary of the Royal Society of Arts, John Street, Adelphi, LONDON.
C.M.	Wrightington, E. N.	Vice-President of the Boston Consolidated Gas Co., 24, West Street, BOSTON, Mass, U.S.A.

ADDITIONAL MEMBERS.

Since the above list was compiled several other applications for membership have been received, including DR. H. E. IVES, of the Physical Laboratory of the National Electric Lamp Association (Cleveland, Ohio, U.S.A.).

The Society has also been privileged to receive the support of MR. F. A. CORTEZ LEIGH, the Chief Electrical Engineer of the London and North Western Railway (Euston Station, London), who has kindly consented to join the Council for the coming Session.

Interior Illumination and the Reflecting Power of Walls and Ceilings *(Discussion).*

(*Continued from page* 289.)

[Discussion of two papers by Mr. Haydn T. Harrison, M.I.E.E., and Mr. P. J. Waldram, F.S.I. on 'The Ratio of Light to Illumination' and 'Some Notes on the Effect of Wall papers on Illumination' respectively, read at a meeting of the Illuminating Engineering Society at the House of the Royal Society of Arts (London), on Monday, April 24th, 1911.]

Mr. A. P. Trotter said that the subject of the reflecting power of wall papers and the colours of the decoration of rooms was of great practical importance, to which architects must be educated up. The subject could be dealt with mathematically by the well-known formula,

$$I = (1 + r + r^2 + r^3 \text{ \&c.}) = \frac{I}{1 - r}$$

where I is the candle-power, and r the coefficient of reflection of the surroundings. Since the reflecting power of the ceilings, walls, and floor is generally different, the mean coefficient must be taken. This is found by

$$r = \frac{a_1 r_1 + a_2 r_2 + a_3 r_3}{a_1 + a_2 + a_3}$$

where a is the area of the ceiling, r its coefficient of reflection, a_2 the area of the walls, r_2 their mean coefficient of reflection, and a_3 the area of the floor, and r_3 its mean coefficient of reflection. It was possible to get a coefficient of a little more than 0·8, that is, more than 80 per cent with the very best white surfaces, and so on down the scale which had been given by several people, especially by Dr. Sumpner, who was the first to publish* a very practical scale of coefficients of absorption of various kinds of papers. The total light in a room entirely covered with various colours absorbing known percentages could, of course, be thus calculated mathematically, but as with many mathematical problems, it was not possible to get at all the conditions, so that in practice it was necessary to have recourse to experiments. The only case in which such calculations were practicable was the Ulbricht globe.

Dr. Ruzicka and Mr. P. J. Waldram have shown that satisfactory photometrical measurements can be made with model rooms. It would only be necessary to colour the ceiling, to paper the walls with actual specimens of wall paper, or with whitewash, for those who prefer that to wall paper, and to imitate the colour of the floor and objects on it, and then to light it with little lamps to scale. A photometric test would be easy, and might be relied upon. If in the real room a 20 c.-p. lamp was placed 4 ft. 6 in. from a wall or ceiling, a ¼ c.-p. lamp would be placed 6 in. from the wall or ceiling of the model.

(An additional contribution by Mr. Trotter to the discussion of Mr. Harrison's paper will be found on p. 325.—Ed.)

Mr. Justus Eck (Union Electric Co.) said there could be no doubt about the great value of having clearly in mind the difference between light and illumination. Mr. Harrison deserved thanks for giving his table of terms. It was the duty of a Society like theirs to try and get clear ideas, and the distinctions given were exactly what were wanted. They wanted something which distinguished the secondary source of illumination from the primary, and he suggested that the Society should, in future, adopt the term "luminosity" as secondary illumination. The suggestion that makers of illuminating devices should send out polar curves was certainly a very good one, but it did not always appeal to the manufacturer, because of the misuse of such curves by their trade competitors. Any manufacturer, however, was always pleased to give such

* *Phil. Mag.*, xxxv. 88, 1893, and *The Electrician*, xxx. 381, 411, 439.

information in response to a serious request from an illuminating engineer, who would put the results to a proper use, and not try to draw improper conclusions to the detriment of any particular piece of apparatus. He regretted that Mr. Waldram had been prevented by ill-health from completing his paper, because the subject was an exceedingly fascinating one. He hoped, however, that Mr. Waldram would on a future occasion communicate to the Society the results of some of the tests which he had in hand. He rather wondered why Mr. Waldram, in the second paragraph of his paper, selected the electrical engineer for adverse criticism. Surely there were consulting gas experts who should provide the same sort of information as was expected to be provided by the consulting electrical experts. In conclusion Mr. Eck expressed the opinion that they could all benefit very greatly from the very interesting model shown by Mr. Waldram, and the demonstration of how it was used for screening off the light from different sections of a wall. He thought everybody must have been greatly impressed by the large amount of ingenuity shown by Mr. Waldram in solving what was an exceedingly difficult problem; many of them thought it could not be solved except at great expense.

Mr. V. H. Mackinney thought that it would invariably be found desirable to use a scientifically designed globe or reflector, even from the standpoint of showing up the walls. Mr. Harrison's remarks in this connexion hardly seemed to emphasize sufficiently the importance of avoiding glare; if glare was eliminated it might be found easier to see objects on the walls, even if the illumination was somewhat diminished.

The essential point to determine was how much light should be allotted to the surroundings and how much expended on the working plane. A study of the polar curves of light distribution of a source, when used alone and with an appropriate reflector, enabled one to state with precision what the results in this respect would be. For example, tests on the latest series of Holophane Stiletto glass reflectors showed that 73 per cent of the light was reflected into the lower hemisphere, 22 per cent transmitted, and only a very small amount, perhaps 3 per cent, absorbed by the glass.

At Mr. Waldram's suggestion he had been making some experiments in a small room, $8 \times 8 \times 8$ ft., in the Holophane Laboratory. This room had a white ceiling and a black floor, and the walls could be covered with paper of any desired shade. Measurements of the horizontal illumination were made in the working plane 2 ft. 8 in. above the floor level. By using a black cloth it was also possible to cover up any section of the room and eliminate its reflecting power, so that the amount of light due respectively to direct and reflected illumination could be very readily ascertained. The results of these tests were shown in the table, and he believed they would enable him in future to predict with some confidence what the probable effect of reflection from surroundings in any ordinary interior would be.

The candle-power and polar curve of the tungsten lamp used throughout were accurately predetermined, both with and without the reflector, so that the direct flux of light on the working plane (shown in the third column) could be easily calculated. The total flux of light was deduced from actual measurements of the illumination with the Holophane Lumeter, and the difference between these two items gives the flux of light due to reflection from walls and ceilings. A further analysis of the reflected light could be made by covering the ceiling with a black cloth and observing the consequent reduction in illumination (this result is also shown in the first line and fourth column of the table).

It is interesting to note that, taking the room with white ceiling and light green walls, the use of the Holophane I 60 reflector leads to an economy in energy consumption of about 56 per cent, while if the darker wall papers were considered an even greater saving would, of course, be obtained.

Naturally the relation between the direct flux and the reflected flux of light depended on the polar curve of

the source adopted. For example, it was to be noted that by using an F type reflector an increased saving could be made, but in this case a rather large amount of light would be removed from the walls, and the illumination over the horizontal working plane would not be quite even.

resulting illumination and that which would have been obtained with white walls. Such a curve, calculated for a distribution similar to that of an ordinary clear bulb tungsten lamp, is shown in Fig. 1.

The use of this factor enabled one to deduce at once how much the energy

Source. Tungsten 200v. 5 w.	Conditions of Ceiling and Walls.	Quantity of Light. (Lumens over Working Plane to the nearest round number). (1) From Source. (Calculated from Distribution Curve)	(2) From Ceiling	(2) From Walls	(3) Total. (Calculated from actual measurement)	Energy Consumption in Watts to give flux of 100 Lumens over Working Plane.
Bare Lamp	White Ceiling / White Walls } Matt Distemper on Wood	17	50	33	100	55
	Black Ceiling (Serge Cloth) White Walls	17	33		50	110
	White Ceiling Dark Blue Walls (Mean Reflective Power 22%)	17	30		47	117
	White Ceiling Dark Red Walls (Mean Reflective Power 28%)	17	36		53	104
	White Ceiling Light Green Walls (Mean Reflective Power 45%)	17	53		70	78
Lamp with Holophane Reflector No. E 60	Ditto	60	40		100	55
Lamp with Holophane Reflector No. I 60	Ditto	90	35		125	44
Lamp with Holophane Reflector No. F 60	Ditto	120	36		156	35

Assuming, however, that a source with a certain polar curve was adopted one could readily deduce from the above figures an approximate relation connecting the reflecting power of the wall paper and the ratio between the

in any interior would have to be increased if paper of a different reflecting value were substituted for that at present used.

The other variable item, involving the nature of the polar curve of the

source used, could be roughly allowed for by the connexion shown in Fig. 2. The abscissa represents the ratio between the flux of light utilized in illuminating walls, ceiling, &c. (in this case assumed to be spread over an

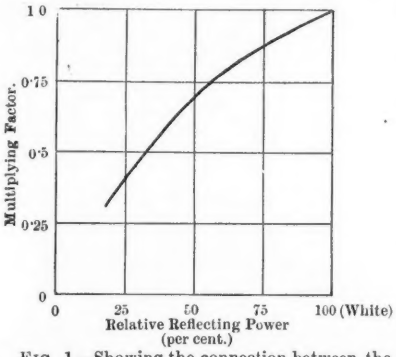


FIG. 1.—Showing the connection between the reflecting power of wall papers and a multiplying factor equal to the ratio of the Horizontal Illumination obtained with white walls and ceilings to the corresponding value secured with white ceiling and walls of a certain reflective power. This curve applies to sources having a polar curve of light distribution similar to the normal clear-bulb tungsten lamp.

angle of 290 degrees) and the flux given to the working horizontal plane (here embracing an angle of about 70 degrees). The ordinates give the corresponding multiplying factor (the value for the clear bulb tungsten lamp being taken as unity).

By the aid of this curve, therefore, we can foretell the change in the energy needed when a source having a certain distribution curve is substituted for the bare lamp. When an appropriate reflector is used with the lamp the amount of light thrown down over the working angle is naturally increased, so that the abscissa ratio is reduced and the energy consumption to secure a certain illumination is correspondingly less. Thus with the I type Holophane reflector referred to above the abscissa ratio would be about 7 (*i.e.* one seventh of the total flux is used to illuminate the working plane) and the multiplying factor is about 0·7. In order to obtain the result shown in the table a further correction for the wall papers used would be necessary, and this could be made with the aid of Fig. 1. The conditions implied by this ratio of 7 seem to represent pretty fairly those usually desirable in actual practice.

This method of dealing with the problem is merely put forward as a tentative suggestion, but it seems probable that the collection of data on these lines would enable one to predict the resultant conditions of illumination with fair exactitude.

MR. THOMAS E. RITCHIE stated that he thought with Mr. Trotter that the papers were hardly such as could be adequately discussed without careful preliminary study. There were, however, several of the matters referred to by the authors upon which he would like to touch.

Mr. Harrison had stated that his tests upon various wall papers had

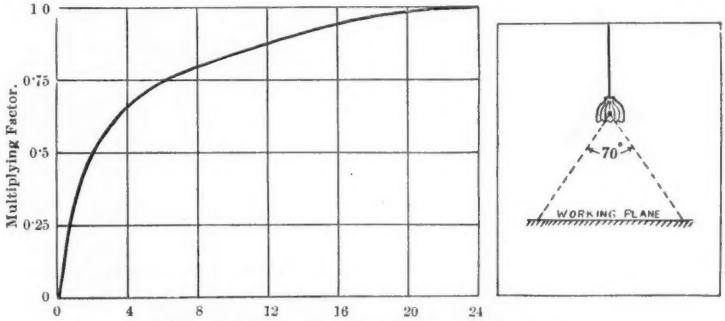


FIG. 2.—Showing Multiplying Factor to be used according to the polar curve of the illuminant.

proved that the angle of incidence of the light rays closely followed the cosine law over the greater part of the angular movement, despite the fact that the surfaces of the papers tested were far from plain ones. This was a point of considerable importance, and he thought that many present would very much like to know over what portion of the angular movement the cosine law was not followed.

As regards the question of the correctness or otherwise of the Lumeter Photometer to which reference had been made, it might, he thought, be of interest to those present—and especially to those who like himself were users of this instrument—to know that he had recently had an opportunity of comparing it with five very well-known and reliable instruments, and in that comparison it came out second, which he thought was a most satisfactory result.

He differed materially from Mr. Harrison in relation to his statement to the effect that shadowless illumination was always depressing. He (the speaker) did not know of any system of illumination which could, accurately speaking, correctly be described as shadowless.

There were systems, with one of which especially certain of those present had thought fit to associate him, which were exceedingly pleasant in that with such the shadows were invariably of very soft and agreeable nature, and were in this respect much more closely allied to the diffused daylight effect, which had rightly been so highly commended by the authors, than anything else with which he was acquainted; but even with these systems, assuming them to be correctly installed, there was always sufficient light and shade effect to give satisfactory relief, and even to satisfy the practical re-

MODELLING IN PLASTER BY INVERTED ARC LIGHTING.
(Note the light and shade effect on the plaster models.)
Illumination: average of 5 readings on floor 4·1 foot-candles, max. 4·9, min. 3·8. Diversity co-efficient 1·46. Current consumption in watts per square foot of floor surface 1·01.

quirements not only of teachers and students of drawing from casts (*Illuminating Engineer*, April, 1911, p. 228), but also of sculptors and modellers in clay and plaster (see pp. 364, 366), and he thought that all would agree that a really definitely shadowless illumination would, if it could be produced, prove most unhappy in practice.

As regards the physiological (light sensation) effect upon a given individual of any particular installation of indirect lighting, which he presumed was the system to which Mr. Harrison referred, this brought him to a point of the utmost importance, and one which he thought had never yet been sufficiently emphasized by the Society, namely, the need for a considerably closer co-operation between the illuminating engineer and the decorative craftsman.

He was well aware that this opened up a very wide field, but as, notwithstanding its width, the field was a most interesting one, and the results which had so far been obtained, and which were yet to be obtained, therein had a very direct bearing upon illumination, he hoped that the Society would take steps to render such co-operation possible, and that practical results would be forthcoming in the near future.

Meantime he might state that the so-called depressing physiological effect of indirect lighting was, as far as his experience went, entirely a matter of colour sensation, and one which could be quite eliminated by the employment of an appropriate scheme of decoration, such an alteration, for instance, as that of the substituting in the place of the stereotyped bluish white of the ceiling and frieze of a warm cream, especially one composed by the addition of pink rather than yellow to the white, completely altering the physiological effect without materially affecting the actual illumination.

He would also like in this connexion to mention that notwithstanding Mr. Harrison's, as he considered, unjustifiable condemnation of indirect lighting, it was, as he could assure them from positive knowledge, now going ahead in this country by leaps and bounds; and although he had made a careful search, he had only been able to find in the records of the Society two instances in which actual installations of indirect lighting by arc lamps had been deemed unsatisfactory. One of these was that recently referred to by Prof. Morris, who, however, admitted that the lamps were used with unscientific reflectors, and that their position relative to the ceiling was determined by considerations of head room rather than of efficiency. The other was the reference recently made by Dr. Bishop Harman to an installation at Cambridge, which, however, as was mentioned by one of the speakers at the meeting at which it was referred to, was installed some fifteen years ago, and related, he believed, to an alternating current system. Moreover, in this particular case the light was, he understood, required for dissecting purposes, which required an illumination, usually local, of the order of from 15 to 20 foot-candles.

Many improvements had been made since that time, and it would probably interest many to know that inverted arcs are now successfully used in the operating theatres of some of the largest hospitals.

He was very surprised to hear of the difficulty experienced by Mr. Waldram in finding illuminating engineers capable of pre-determining with reasonable accuracy the gain in illumination due to reflection from the walls and ceiling. He agreed with him that the number of those possessing such knowledge was not yet large, but thought that the services of such had been available for many years past. Although at that time very few reliable co-efficients of reflection were available, he distinctly remembered having the importance of the influence of the reflected light from the wall and ceiling impressed upon him in his apprenticeship days, and had since that time usually taken such into account in calculating the illumination of interiors, and had always done so in the case of indirect lighting.

He thought that in bemoaning the inability of manufacturers to supply polar and other curves relating to their lamps, both authors had adopted a

somewhat unnecessarily pessimistic attitude, as there were at all events some firms who had for many years been in the habit of furnishing, when called upon, most helpful information of this kind.

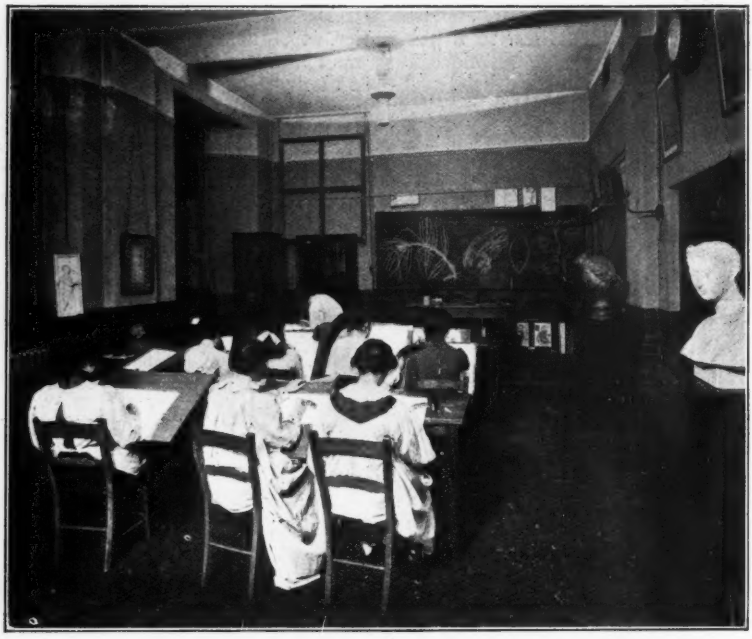
He considered that the fault lay quite as much with the architects and illuminating engineers as with the manufacturers, who were very rarely asked for such information, and who when putting forward such curves not infrequently found that they were not correctly understood.

Finally he entirely agreed with, and desired to emphasize, Mr. Waldram's point, that the secret of all successful artificial illumination is to therein approximate as closely as we can to the diffusion conditions of daylight under which our eyes have developed.

MR. J. G. CLARK agreed with the view brought forward by Messrs. Harrison and Waldram, that a complete polar curve was the most satisfactory method of rating lamps. Such curves would do much to simplify illuminating engineering.

In regard to lighting: as pointed out by Mr. Waldram, where any architectural or colour scheme exists it must, of course, be taken into account. In his—Mr. Clark's—experience a comparatively low illumination sufficed for this purpose, such, for instance, as was produced by the rays transmitted through an opal or Holophane reflector.

In regard to the data for determining a lighting scheme based upon illumination, it would appear that a large amount of work would have to be done along the lines suggested by Mr. Waldram. Rooms vary so much in form as well as in other ways. It had occurred to him that for a given form of room and a given scheme of decora-



DRAWING AND DESIGNING BY INVERTED ARC LIGHTING.
(Note the light and shade effect throughout the picture.)
Illumination: average of 10 readings on desks in front of students and on teacher's table 3·8 foot-candles, max. 5·2, min. 2·9. Diversity co-efficient 1·78. Current consumption in watts per square foot of floor surface 1·83.

tion, the illumination produced by a given light flux would be approximately inversely proportional to the square of the linear dimensions.

A simple rule of that kind would, if fairly true, be found useful.

MR. W. R. RAWLINGS, while congratulating the authors upon their papers, thought they had overlooked one or two important points, such, for instance, as the comfort which was to be derived from the light itself, or from the luminosity. The suggestion seemed to permeate the papers, that it would be far better to have white walls. Again, it seemed to be suggested that all rooms were somewhat of the shape of the rooms referred to in which the tests upon different coloured wall papers had been carried out, but in actual practice it was found that rooms had alcoves, and that the walls were hung with pictures and curtains, and all these had to be taken into consideration when dealing with the illumination. They did not want to fix a volume of light throughout the room. Each room must be dealt with upon its merits. In a dining-room, for instance, the light was wanted on the table, and much as Mr. Haydn Harrison knew of illumination—and they would all admit that it was very considerable—he ventured to suggest that he had still to learn something in regard to the requirements of the ladies in connexion with illumination. Mr. Harrison had suggested that ladies wanted more light than the gentlemen, but he was sure that Mr. Harrison knew nothing about ladies if he adhered to that statement. When ladies went out in sunlight, they usually put on a veil in order to leave something to the imagination, and when it came to artificial lighting the same idea seemed to prevail, because he was frequently told, when dealing with the boudoir and the drawing-room, "Please do not let me have a bright light." In the same way, in the smoking room it was usually necessary to have a very bright light, and he differed from Mr. Harrison on these two points. Nevertheless, he congratulated the authors upon bringing forward a matter of very great interest indeed, and he was particularly interested in the way in which Mr. Waldram measured the luminosity in different parts of the room.

MR. J. HEWITT said that both papers had dealt with the matter from the point of view of house lighting, pure and simple, and in this connexion there was one thing that had to be considered very carefully, viz., the avoidance of eye strain, and the effect of sudden transit from darkness into a bright light, and also the avoidance of direct light into the eye. Of course, if the source of illumination was not to be visible, there was then an entire avoidance of eye strain. One difficulty which the ordinary illuminating engineer came across in practice was the trouble he often had with the architect who was employed on the job. As an instance, he mentioned a case in which he was concerned, in which he had designed very carefully the whole scheme of illumination for a building in which there were a large number of oil paintings. He had previously seen the architect, who had given him particulars of the scheme of colouring, and everything else. But when he went down to the job afterwards, he found that the blue was a great deal deeper than that given to him, the brown was nearly as dark as the hall of the Society of Arts, and there were heavy oak beams which had been shown white in the drawing. The result was that he had to alter everything. He asked Mr. Harrison to explain to him more clearly the sense in which the term "diffusion" was used in his paper. The meaning he put upon it was that it related to the light coming from every possible point. Personally, he failed to see that they could get any approximation to this, and as no doubt the point had occurred to many others, perhaps Mr. Harrison would make it clear.

THE CHAIRMAN (Mr. R. J. Wallis-Jones), in proposing a vote of thanks to the authors of the papers, said that contributions of this description justified the existence of the Society. Mr. Harrison's paper brought out a figure which was quite satisfactory to him personally, namely, that the light green gave very good reflective results, a fact that he had mentioned at the

last meeting of the Society. If anybody had any doubts as to the reflective value of various colours, he did not think there was a better object lesson than by going into Oxford Street and seeing a certain building where there were a large number of windows all lighted in exactly the same way, and if they observed the windows which had dark materials in them, the lighting appeared to be most inferior as compared with the windows which had lighter materials. Mr. Waldram's paper might very well have had a sort of text which would read something like this, "Dull walls, dull spirits"; and he thought it was a valuable suggestion of Mr. Waldram's that the Council should try and draw up standards of brightness of illumination for different classes of interior work. He had no doubt that the Council next session would give this suggestion consideration.

MR. JOHN DARCH (*communicated*).—In response to the invitation of the chairman I have pleasure in forwarding my views upon the papers read by Messrs. Harrison and Waldram. There are few subjects that, at the present moment, need investigation more than "the ratio of light to illumination," and it was a happy thought to have a paper thereon. We had an excellent paper, but I should have liked to have heard something more about "the ratio of light to illumination." However, information of high importance was brought forward dealing with the ratio of illumination to surface brightness, and both gentlemen deserve our thanks for their efforts to elucidate a subject that has been too long neglected; there is, however, much more to be done in that direction: facts and figures need to be gathered together, carefully digested and reduced to a system.

Mr. Waldram's forcibly expressed views on the advantages of utilizing the reflecting and diffusing properties of walls and ceilings should be taken to heart by every lighting engineer—success lies that way—but, of course, the walls and ceilings must be so finished as to be capable of a usefu amount of reflection and diffusion, and therein lies a difficulty: we trespass upon the architect's and decorator's domain. At the same time, I see no reason why the illuminating engineer, without materially interfering with the scheme of decoration or colour desired by an architect, might not very well advise as to the average amount of reflection necessary for proper illumination—which he could define in the form of a coefficient—since a slight percentage of variation in the depth of colour, that would make little difference in the scheme artistically, would yield an enormous advantage in its illuminating value. To facilitate the selection of wall papers suitable to any

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scheme of illumination, as well as decoration, the makers of those papers should ascertain and state the coefficient of reflection (in the case of uniformly coloured papers) and the average reflection (in the case of figured papers) on the backs of the patterns; and from what I know of many of the makers I think they would be only too pleased to do so. It is for us to represent the matter to them and to help them in finding the coefficient.

It was not unnatural for Mr. Rawlings to think that the writers of the papers were pleading for white interiors; but that was not the case; they were pleading for interiors that would not nullify illumination and that would conduce to economy and personal comfort; but, so far from advocating a white interior, Mr. Waldram particularly advised the employment of coloured surfaces "as a relief from a trying uniformity." The eye needs a good light for many forms of work, but it also needs a means of escape from the prolonged batter of light and heat rays from brilliantly illuminated surfaces, and, following Nature, who has spread for us a light absorbing carpet and surrounded us with a sombre arboreal

dado—all calculated to give relief from the glare of sunny skies—we should cover the floor and lower part of our rooms with materials in comparatively subdued tints.

Following this, another point to be constantly borne in mind is that our sense of illumination is governed solely by the light which enters the eye, so that while it is of great importance that we should obtain the highest ratio of illumination from a given flux of light, it is of even greater importance that the illumination should be adjusted to produce the best effect—physiologically and psychologically—and to ensure the greatest visual acuity.

On the Nomenclature of Photometry.

Mr. Harrison did well to call attention to the meaning of certain technical terms that are becoming, and will become, the commonplaces of the platform and the office. He pointed out that some uncertainty still existed as to their true meaning, but I am afraid that he is not mending matters by introducing new interpretations to words the meanings of which are sufficiently well established, and I feel that a little friendly criticism is necessary. For example, it is suggested that we should use the word *lumen* to represent "the value of indirect or secondary sources of light instead of candle-power," and to use *foot-candles* "for direct light from a source"; also to describe a given area in a room as illuminated by so many foot-candles and so many lumens, as if foot-candles were a measure of quantity and comparable with lumens. As far as I am aware, there has never been but one conception of the word lumen, and the definitions of Drs. Chas. Steinmetz, Carl Hering, Laporte, Krüss, and Wickenden are identical.

The foot-candle is a measure of intensity, not of quantity of illumination, and, like electric pressure without current, so foot-candles without surface is nothing, and surface therefore becomes a necessary factor in measuring quantity, the unit of which is the *lumen*, representing the intensity of illumination at a surface multiplied by the area illuminated. Thus,

$$\text{Quantity in lumens} = \frac{I \times A}{R^2}$$

I being the candle-power of the lamp at right angles to A the area of the surface at a distance R. When the rays are oblique to the surface, the cosine of the angle becomes an additional factor. A and R are usually expressed in feet in England and America, and in metres on the Continent; the fact, however, remains that a lumen is, and must remain, the unit of measurement of the illumination of a surface *from a source*.

Mr. Harrison's well-meant suggestions, given in a list of six definitions, for a revised interpretation of our leading photometrical terms can, I fear, but increase the very confusion that they are designed to prevent. Let us remember that although luminosity, brightness, brilliancy, glow, incandescence, radiance, and luminescence all represent the one and same idea of the shining of a body, and are often used indiscriminately, they are by no means reciprocal terms, and in dealing with technical matters, must be used strictly in their proper relation and with due respect to their derivation. Thus, "incandescence" implies that a body is giving light because it is hot, but "luminosity" possesses the opposite idea in that it refers only to that portion of radiant energy which excites vision and therefore excludes heat. "Light" (def. 1), has a more extended meaning than "luminosity" (def. 6), otherwise they are essentially the same.

"Brightness" (def. 3) and "brilliancy" are not quite the same, although many lighting engineers use them interchangeably, but whether any useful technical distinction will ever be established remains to be seen. There is, however, a lexical difference which is worth noting: "brightness" is a generic term, a simple statement of the condition of a body; "brilliancy" is specific and arises out of the brightness; the brilliancy of a surface follows from its brightness, not its brightness from its brilliancy. In either case the simple words "brightness" and "brilliancy" should be used only in a general sense, and never in respect of photometrical quantities, for which purposes the

best authorities invariably use the terms "intrinsic brightness" "intrinsic brilliancy," "surface-brightness," &c., all definable in candle-power per square c.m., inches or feet. It will therefore be seen that "luminosity" (def. 6) is not the same as "brilliancy."

Then, again, why should the term luminosity be applied only to secondary sources of light? What is to become of "the luminosity of flames," "the luminous rays of the sun," "the luminous intensity of"—well! any primary source wherewith we distinguish the visible from the actinic and heat rays?

Finally, "illumination" (def. 2) can hardly be defined as "the extent to which anything is illuminated," but the simple fact that it is illuminated; and it is not the extent but the intensity of the illumination that is measured in foot-candles.

In submitting these criticisms, I should like to express my appreciation of Mr. Harrison's paper, and feel that his suggestions have been very serviceable in leading to fruitful discussion.

MR. J. S. DOW (*communicated*).—There are a number of points in Mr. Harrison's interesting paper that seem to invite comment. Mr. Harrison, if I understand him correctly, applies the term "lumen" to denote "luminosity" or surface brightness, which is expressible either in foot-candles or candle-power per square inch. This is surely inconsistent with the definition habitually adopted by authorities in the United States and on the Continent (such as Sharp, Liebenthal, Blondel, and many others), who use the term to signify "luminous flux," and I observe that the word has been used in this customary sense by Mr. Mackinney. We should therefore exercise caution in making a radical departure from existing usage in this matter.*

There is much to be said for Mr. Harrison's desire to separate the illumination due to direct flux from the source and that due to reflection from walls and ceiling; but in both cases *the same units* would seem to be necessary. Would it not be better, therefore, to speak of "primary" or "secondary" flux or illumination as the case may be; or to adopt some form of suffix such as is employed to distinguish between spherical and hemispherical candle-power?

The method I have sometimes employed, of expressing surface brightness in terms of foot-candles, has the sanction of Prof. L. Weber,* but seems not to commend itself to Prof. Blondel.† It may be suggested that in many cases foot-candles is really a more convenient unit than c.-p. per square inch. For example, when comparing the surface brightness of walls with the actual illumination producing this brightness, it is convenient to use this unit. Moreover, in speaking of an illumination of so many foot-candles one instinctively thinks of a white surface illuminated to this value; hence such a brightness of a piece of white paper illuminated with 3 foot-candles is a fairly familiar conception to many people. When one suggests that a wall ought usually to have a surface brightness of 0·3 foot-candles a lighting engineer readily forms an idea of what is required. Also knowing the reflection coefficient of the wall paper, he can at once deduce what illumination he must produce in that locality to secure such a brightness. But to say that the surface brightness should be 0·00065 c.-p. per square inch, on the other hand, would hardly convey to most people a good impression as to how bright the wall ought to be, nor how much illumination is needed to secure this brightness. On the other hand, in dealing with inverted lighting and ceilings which act as powerful sources of light, it may sometimes be useful to employ c.-p. per square foot (or square inch) of radiating surface; personally I prefer to use the phrase intrinsic brilliancy if this method is used.

In his reference to the Holophane Lumeter Mr. Harrison raises several points of fundamental interest in measuring illumination. The surface on which the illumination is received

* See Tables of Definition: *Illum. Engineer*, Lond., vol. iv., Feb., 1911.

* See *Illum. Engineer*, Lond., vol. iii., 1910, p. 116.

† See *Illum. Engineer*, Lond., May, 1911, p. 265

should naturally be as white and matt as possible, and I venture to think the screen used with the Holophane Lumeter answers these requirements exceptionally well. But surely it is not necessary for this surface to be identical with that inside the instrument? The sole requirement seems to me to be simply this—that the actual surface used in calibrating the instrument should subsequently be used for tests of illumination. With this condition we naturally comply.

I think, therefore, that Mr. Harrison will agree that the principle here adopted in measuring illumination is quite correct and is similar to that followed in other illumination photometers, which are calibrated before use. The determination of surface brightness is an additional advantage, and the process of measurement in this case appears to me equally correct. I quite agree with Mr. Harrison, however, that people must naturally be clear in their minds as to which of these two quantities, illumination or surface brightness, they desire to measure, and that in recording results they should be very careful to distinguish between them.

Mr. Waldram rightly lays stress on the need for a standard of brightness for walls. As a result of measurements in libraries and private houses I am inclined to suggest that a surface brightness of 0·3–0·4 foot-candles usually suffices to render a room "cheerfully" lighted rather than subdued. The illumination necessary to secure this brightness naturally depends upon the reflection coefficient of the wall paper; as an approximation, one might suggest that a wall illumination of 0·5 to 0·75 foot-candles will usually be found desirable. This, of course, is subject to some latitude. In the case of rooms devoted to study, with plain walls, a lower figure might often be allowed; but an interior containing valuable pictures, china, &c., would probably require more.

Mr. Haydn Harrison, in reply to the remarks of Mr. Trotter, agreed that mathematically certain illuminating results would occur under known conditions of light and reflection; but the point which he had raised in his paper was that, even if the illumination on a given surface could be calculated, it would still be impossible to state whether that illumination would be satisfactory unless the source or sources of light, position, and area of same were defined. For instance, if in a case of indirect lighting equal illumination were derived from all directions, however powerful that illumination, monochromatic solid objects would appear flat, as there would be no degrees of light and shade. Whereas, if the same degree of illumination were derived from a light source having radial light emanations, the solid objects would stand out in relief, therefore less illumination would be necessary in order to see the details clearly. Hence illumination in foot-candles is not the only unit necessary for simple definition of illuminating efficiency, and he suggested a word to distinguish between radial and dispersed flux of light.

Mr. Hewitt also touched on a point on which he (Mr. Harrison) had laid emphasis, viz., eye-strain; but Mr. Hewitt had only mentioned that form of eye-strain which was due to sudden transit from light to darkness. The eye-strain which he (Mr. Harrison) suggested should be avoided was that due to the use of wall papers, &c., which reflect a large percentage of light back into the eye, thus preventing any possible rest.

In reply to Mr. Hewitt's question of the term "diffusion," it is used in the paper as referring to sources of illumination which are of such area as to reduce radiation considerably, and thus eliminate shadows.

Mr. Harrison was glad that Mr. Eck agreed with him as to the importance of distinguishing primary and secondary illumination, and hoped the Society would agree upon some terms for the purpose. But he could not agree with Mr. Eck that any manufacturer was pleased to give information concerning the polar curves of their lighting devices, as many of them had not got the information themselves.

In reply to Mr. Ritchie, Mr. Harrison mentioned that in the case of the wall papers he had tested, the cosine law followed over an angle exceeding 45 degrees on either side of the direct angle; beyond that he had not tested. As regards the correctness of the Lumeter, he found it to be excellent, provided the illumination tested when large colour differences existed was sufficiently low, or lowered by using the absorption screen. Mr. Ritchie's remarks *re* shadowless illumination were no doubt based on indirect illumination by arc-lamps; but he himself did not call this shadowless as the sources of illumination were few. The shadowless illumination he was thinking of was more of the nature of indirect cornice illumination or multitudinous light sources in all directions. Mr. Harrison quite agreed with the emphasis Mr. Ritchie placed on colour sensation. Unfortunately, most of the colours useful for reflecting artificial light were of a cold and depressing nature. With reference to Mr. W. R. Rawlings's remarks, it was obvious that he had not realized how much Mr. Harrison agreed with him as to the comfort derived from the light itself.

Mr. V. H. Mackinney's valuable contribution to the discussion deserved a paper to itself, but as far as reference to his short notes was concerned, his remarks went to emphasize the importance of more clearly defining the relative "seeing value," if that term may be used, when comparing direct radial and indirect diffused light.

Mr. John Darch (*communicated*) complained that he had heard nothing about the ratio of light to illumination. Mr. Harrison was sure Mr. Darch would not like to have heard over again the laws with which he is no doubt familiar, therefore he had endeavoured in his short notes merely to suggest that the ratio of light to illumination is not always what it seems, and that there are several factors, for which we even have no name, which require the most careful consideration of illuminating engineers. He was glad Mr. Darch took his suggestions of photometrical terms as well meant, and if they did lead to worse confusion probably it would be worth somebody's while to straighten them out once and for all. But in any case he would not plead guilty to confusing foot-candles and lumens, though he suggested the use of foot-candles and luminosity to distinguish between the light derived from primary and secondary sources respectively. This naturally led to a unit to distinguish foot-candles and illuminating value derived from a secondary source, which of course could be measured in foot-candles, but could be distinguished by another term.

Mr. J. S. Dow's (*communicated*) remarks call attention to the fact that his proposals clashed with the definitions as used in the States and on the Continent. Mr. Harrison granted this, and therefore could only see as an alternative the use of further terms added to the somewhat long list already existing. To use the words primary and secondary flux would not indicate the nature of flux as to whether it was radial or otherwise. As regards foot-candles and candles per square inch, their value as an indirect light source depended again on whether the square inch was flat or round, plain or rough. Therefore it was important to consider whether it was viewed as an illuminated object or as an illuminating or light-giving object, and for this reason he wished to have distinguishing terms. Mr. Dow was quite correct in assuming that he agreed as to the correctness of the principle embodied in the Holophane Lumeter, especially if the instrument were empirically calibrated. In conclusion, he wished to express his thanks to those joining in the discussion for their kind remarks concerning his short paper, which was only put forward as a foundation for discussion; this had already proved more valuable than the paper which originated it.

Mr. Waldram also replied briefly. With regard to Mr. Trotter's suggestion that experiments should be carried out with model rooms, he said these were not easy except for table plane measurements, but probably the difficulties could be overcome. It was

first necessary to find out whether experiments in a room, say, 10 ft. square were comparable with a room 100 ft. square, and he was inclined to think they would be. He had recently found that results obtained in a room 20 ft. by 10 ft. by 10 ft. high were almost the same proportionately as in a room 135 ft. by 60 ft. by 30 ft. high. Thus it would seem that it did not seriously matter what size the room was in which the experiments were carried out. He disagreed with Mr. Clark as to the illumination of a room varying according to the square or the linear dimensions. He would have thought that in a white room they would vary according to the linear dimensions, and not according to the square. Mr. Eck had been rather sorry that he had not criticized gas experts in his paper, or rather that he had left them out. He was afraid the difficulty was, speaking as an architect, that he found neither gas nor electrical experts could generally guarantee to provide a wiring installation which would give a certain foot-candle illumination in a given room. That was the difficulty he had found as an architect, but he must say that he had been able to get considerable help in this respect from the Holophane Ltd.; it was his experience that if he wanted to get a certain amount of illumination, say, on a rinking floor or a dancing floor, or, indeed, on any floor, he could get information concerning it from the Holophane book. When it came to walls or ceilings it was not so easy. Mr. Mackinney took the table plane, but he hoped that they would not neglect the walls and ceilings. Mr. Rawlings seemed to be rather afraid that he was suggesting white walls. As a matter of fact, white walls and also white ceilings were largely used in America for economy, and their economy was obvious, but economy was not the only factor. There was need for standards of brightness for different coloured papers, and he hoped some action would be taken in regard to this. With regard to Mr. Rawlings's suggestion that a very good light was wanted in a smoking room, he suggested that in an ordinary West End clubroom it was more useful to have particularly dark colours and walls, and particularly bright lights on the card tables.

He was very glad to hear from Mr. Ritchie that he and others had been in the habit of predetermining the illumination to be derived from walls and ceilings for some years past. Unfortunately, the technical press appears to contain no record of the methods adopted, and Mr. Ritchie was also silent on the point. Nor did he say whether the approximate standards arrived at in the paper agreed with the wealth of experience to which he referred. The time and trouble which he had expended in endeavouring to elucidate the principles governing what he had imagined to be a factor hitherto undetermined would not be wasted if it succeeded in drawing from Mr. Ritchie a more complete treatment of the subject.

He agreed with Mr. Dow that 0·3 to 0·4 foot-candles apparent surface-brightness gave a distinctly cheerful effect, but it must be remembered that 0·4 foot-candles *coming from* a dark wall paper does not necessarily give the same general impression as 0·4 coming from a wall of lighter shade. He would suggest that if all classes of interiors were classified for satisfactory surface-brightness, the classification should be with reference to light and dark papers.

He was much relieved at the absence of any violent criticism of the principles which the paper suggested as being those upon which the subject should be solved, viz.: Firstly, the fixing from standards yet to be determined of satisfactory surface-brightness for walls and ceilings and for table plane illumination. Secondly, the calculation of the direct flux from any lamp or globe from its polar curve. Thirdly, the addition to that direct flux of percentages (still requiring more exact determination) due to reflection; and lastly, the conversion of real flux on walls and ceilings into apparent surface-brightness by means of reflection coefficients.

In conclusion, he desired to express

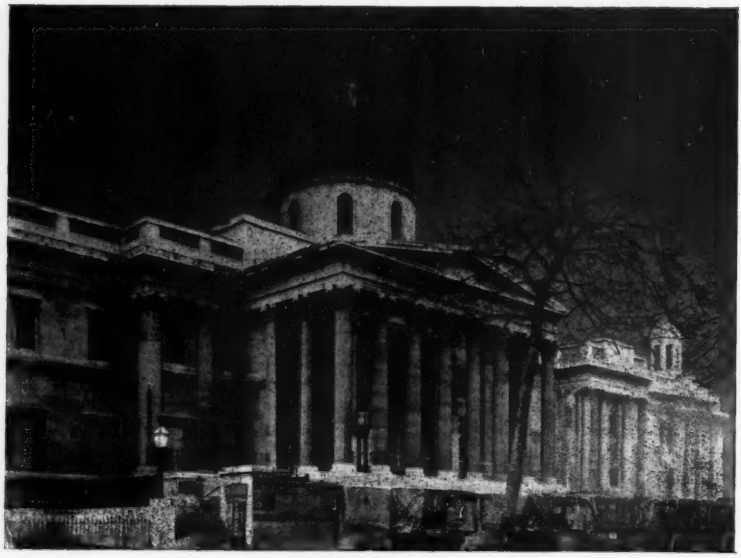
his indebtedness to Mr. Dow and Mr. Mackinney, who had rendered valuable assistance in the experimental work; to Holophane, Ltd., Company for the loan of apparatus, lamps and shades, to Mr. Partridge of the London Electric Supply Corporation who had kindly rendered possible, at very short notice, the necessary temporary installation; and to Mr. Harrison, whose assistant, Mr. Taylor, had spent some laborious hours assisting at the tedious work of taking and averaging results.

An Interesting Photograph by Artificial Light.

THE accompanying illustration, showing a view of the National Gallery (London), was taken about 11 o'clock at night by the unaided light from the street lamps.

In practice the eye is often so affected by the "glare" from the lamps in our streets that it does not truly appreciate the variety of light and shade in buildings illuminated by their rays. In the same way in photographs of the streets taken by artificial light, the lamps not infrequently appear the most conspicuous objects, and the surroundings appear indistinguishable.

In taking this photograph the actual surface-brightness of different parts of the building and the sky were measured by the Holophane Lumeter, and the exposure regulated accordingly.



The surface brightness of the lightest parts of the building was about 0·05 foot-candles, that of the sky about 0·01, and that of the dark dome even less.

Such photographs give us an idea what our streets would look like if the glare of artificial sources could be completely avoided.

Short Notes on Illuminating Engineering.

From all Sources.

A Method of Artificial Illumination for Picture Galleries.

COMPARATIVELY few attempts have yet been made to light picture galleries artificially in this country, and a method adopted in the Morgan Art Gallery at Hartford, Conn., U.S.A., is therefore of interest.

In this building the daylight illumination comes from overhead skylights, and it was determined to contrive the artificial illumination on the same plan. Tungsten lamps equipped with special focussing reflectors were placed outside the skylights two feet above a screen of special sand-blasted glass. By this means a diffused illumination closely resembling daylight was secured.

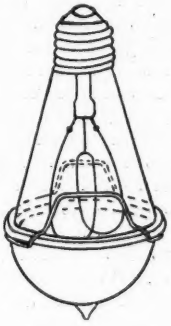
The glass was only slightly obscured and was not completely "diffusive." Had it been so the light would have been directed equally in all directions in an uneconomical manner. For example, much light would have been shed on the floor instead of the pictures. By the aid of the special mirrors the light was mainly concentrated on the walls where the pictures hung, the slightly obscured glass serving to reduce the glare without affecting the *direction* of the light.

The arrangement might thus be compared with the sun shining through a light mist which serves to modify the high intrinsic brilliancy of the direct rays without absorbing too much light.

Colour Caps for Glow Lamps.

Coloured glow lamps would probably be more widely used than they are at present for advertising and decorative schemes if it were not for the difficulties and expense connected with them.

If the whole bulb is of coloured glass the lamp is expensive, while the methods of staining the bulbs, although cheaper, are often not reliable. Stained bulbs will not always withstand exposure to the weather.



The device shown in the accompanying illustration, and described recently in *Electricity*, has been used in America as a means of overcoming some of these difficulties. A coloured glass cap is sprung over the bulb of the lamp as indicated in the sketch. Any type of lamp may be used, and the colour scheme can be altered at any time by changing the caps.

Blue Light for Displaying Diamonds.

In the recent discussion on shop lighting reported in the *Transactions* of the American Illuminating Engineering Society, Mr. V. R. Lansingh drew attention to the value of light of a bluish tinge in jewellery departments. Light of this kind served to show off to advantage the more valuable diamonds which are of a blue colour, and to enable them to be readily distinguished from the inferior varieties which are yellowish. It has been found that an arc lamp with no coloured globe of any kind, but simply a shade of prismatic glass to diffuse the light, gives very satisfactory results for this purpose.

Porch Lighting.

Porch and doorway lighting can be vastly improved by the use of portico lamps. We have installed about 70 of these lights in front of doctors' office doorways, and we have two in back yards. A good field for this kind of lighting is with physicians. Many of these lamps have replaced the oil lamp on a bracket, but more have replaced the 16 candle-power electric lamp so frequently seen in front of a doctor's residence. An incident came to the writer's notice some time ago. A certain boarding-house keeper had occasion to seek a physician late at night. He passed at least four, until attracted by the bright light from a portico in front of a well-known doctor's house on Massachusetts Avenue. He went to him and later told him that, if the light attracted people to his office, there was no reason why they could not be attracted to his boarding-house in the same way. So he had one put in.—W. S. Farrow, *American Gas Light Journal*, April 17th, 1911.

Police Regulation of the Lighting of Fairs.

With a view to minimizing the risk of fire with the temporary lighting arrangements which are frequently installed at fairs and open-air markets at Paris, the Police authorities have issued regulations which forbid or limit the use of certain illuminants.

Briefly, petrol and alcohol vapour lamps are entirely forbidden, but acetylene is allowed for exterior lighting, and for the lighting of interiors where the public is not admitted, provided that the installation consists only of dissolved acetylene apparatus, or small portable lamps not containing more than two kilos of carbide.

A writer in the *Revue des Éclairages*, commenting on the regulations, points out that they are not yet very rigorously enforced, judging by the number of vapour installations which may be seen at fairs. It is suggested that until detailed instructions are issued to the police, it will be difficult to discriminate between what is permitted and what is not.

The writer concludes with a plea for fair treatment of the various illuminants, and expresses the desire that the regulations should be made logical and clear so as not to give rise to unnecessary disputes.

The Effect of Quartz Lamps on Plants.

Electrical Industries contains an account of some experiments recently carried out by Mr. William Priestly on the effect of Quartz mercury-vapour lamps on the growth of plants.

It was found that in the case of seeds placed close to the lamp without the usual glass screen, germination is prevented; but if the screen is in position, thus cutting off a large proportion of the ultra-violet rays, growth seems to be greatly accelerated, and the plants developed are of quite a sturdy type.

Combined Classes for Electricians and Gas Workers.

Classes have recently been established by the Municipality of Rome for the instruction of electricians and gas-fitters.

It is interesting to note that in these classes the men for whom the advance course is exclusively intended, work together, and thus acquire a preliminary knowledge of both gas and electric lighting, a general knowledge of this kind being regarded as desirable in both cases.

Recent Experiments with Invisible Light.

SOME time ago we had the pleasure to refer to some remarkable experiments described by Prof. R. W. Wood of the Johns Hopkins University, in the Thomas Young Oration before the Optical Society.

At the Royal Institution on Friday, May 19th, 1911, some other remarkable researches were described. Photographs taken by the invisible light could be secured by using a Quartz lens covered with a very fine film of silver. Such a lens is opaque to visible light, but transparent to ultra-violet rays.

Various photographs obtained in this way were thrown upon the screens, together with corresponding pictures made with visible light, some very striking effects coming out. White garden flowers came out black, the glass windows of a porch appeared as opaque as if made of sheet iron, and a man standing in full sunshine was seen to cast no shadow at all, proving that the ultra-violet rays come chiefly from the sky, that is, they are diffused by the atmosphere, comparatively few reaching us directly from the sun. The study of the moon in ultra-violet light was next dealt with. The discovery was made that the bright crater Aristarchus is surrounded by a vast deposit of some sort which comes out black in the photographs with ultra-violet light while it is scarcely visible in the case of ordinary light.

Some experiments were described in which the region in the air surrounding an electric spark photographed with ultra-violet light appeared luminous, and it was subsequently ascertained that the spark gives off some obscure radiation which excites a phosphorescence of the air. The radiation is incapable of passing through any material substance, and it is not reflected from polished mirrors. It is suspected that it is a very short wave radiation intermediated in position between the extreme ultra-violet region and the X-rays.

The lecturer mentioned briefly some experiments made in collaboration with Prof. Rubens of Berlin with a new device for isolating very long heat waves. Rays were obtained in this way with a wave length of over one-tenth of a millimetre, or about 300 times as long as a light wave. More recently Prof. Rubens has found with the same apparatus waves one-third of a millimetre long which are given off by the mercury arc. Various peculiarities of the mercury arc were spoken of, and some curious samples of fluorescent cloth were shown which appeared scarlet under the light of lamps whereas ordinary red cloth appears nearly black.

Combined Lighting (Gas, Electricity, and Candles) of a Famous Hall.

ON May 18th a complimentary dinner to Sir John Wolfe-Barry, in recognition of his valuable work as Chairman of the Engineering Standards Committee, took place at the Goldsmiths' Hall (London). The lighting of this hall is of considerable interest to illuminating engineers. Not only is the general effect very pleasant but, apart from this, it is to be observed that three alternative systems—gas, electricity, and candles—are available. We hope to refer on a future occasion, and more fully, to the excellent lighting of this famous hall.

Lectures in Advanced Engineering.

OUR attention is drawn to a course of five lectures on 'The Application of Hyperbolic Functions to Electrical Engineering Problems' which is being given at the Institution of Electrical Engineers (Victoria Embankment, London, S.W.), at 5.30 P.M., on May 29th, 30th, 31st, June 1st and 2nd, 1911, respectively, by Dr. A. E. Kennelly of Harvard University, U.S.A.

Dr. Kennelly will also be known to readers of this journal as the new President of the American Illuminating Engineering Society, and we have no doubt that this course of lectures will be found most valuable by many advanced engineering students.

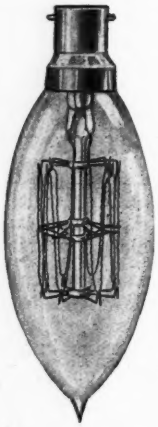
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

"Tantalum" Candle Lamps.

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that they are now placing on the market a further range of 'TANTALUM' CANDLE LAMPS, an illustration of which we reproduce herewith. Hitherto these lamps have not been supplied in higher voltages than 60, in 5 and 10 candle-power sizes, but the new types



will be supplied in 10 and 16 candle-powers for 70 to 120 volt circuits. The filaments will be of drawn Tantalum, and the efficiency will be precisely the same as that of the ordinary 'Tantalum' lamps at present on the market. The lamps are approximately 5 inches long and 1¾ inches in diameter, and are suitable for series burning in candelabra fittings on high voltage circuits.

We have also received from **Messrs. Siemens Bros. Dynamo Works, Ltd.,** two illustrated price lists of accessories for lighting installations, including switches and plugs, and some examples of electric heaters.

A "Screwless" Gallery.

The accompanying illustration shows a new type of gallery suitable for fixing any shade or reflector which **Messrs. Siemens Bros. Dynamo Works, Ltd.** (Tyssen Street, Dalston, London, N.E.), have recently put on the market. The essential feature of the gallery is that it has a spring grip on the glassware, thus doing away with the necessity of loose

Patent No. 950.

screws which are so often a source of trouble in the ordinary gallery. When the gallery has been sprung into position over the lip of the shade, a ring, sliding on the outside, is pressed down so as to ensure absolute security. It is interesting to note that attention has been paid to the depth of the gallery, so that when using metal filament lamps and Holophane reflectors the lamps are brought into the true focus of the glassware.

We have received from **Messrs. Feld Bros. & Co., Ltd.** (25, Budge Row, London, E.C.), a price list of 'GRAETZIN' METAL FILAMENT LAMPS, accompanied by a report of an official test recently carried out at the Physical Laboratory, Charlottenburg.

Out of nine lamps tested, all were still burning after 6,000 hours, the decrease in efficiency at the end of this period being about 30 per cent. The remarkably long life shown by this test is good testimony to the strength of the filaments which is claimed to be a special feature of the 'Graetzin' lamp.

The South Metropolitan Gas Co. (709, Old Kent Road, London, S.E.), have sent us an illustrated booklet dealing with the economical production of hot water by gas-heated circulating boilers. By this method, it is stated, hot water can be obtained for the bath, &c., more quickly and more economically than by the ordinary range boiler. It is further pointed out that the inconvenience, especially in the summer months, of having to light the kitchen fire in order to obtain hot water for a bath, is removed by the use of a gas-heated boiler.

Messrs. The British Westinghouse Electric and Manufacturing Co., Ltd. (Trafford Park, Manchester), wish to contradict a statement which appeared in some of the reports of the General meeting of the Company recently, to the effect that they are about to cease the manufacture of gas engines. The statement was due to a misunderstanding, and is entirely erroneous.

Holophane Lumeter.

Messrs. R. & J. Beck, Ltd. (68, Cornhill, London, E.C.), send us an illustrated pamphlet descriptive of the HOLOPHANE LUMETER, an instrument which has been previously described in our columns.* The pamphlet indicates briefly the class of measurements which the Lumeter is specially adapted for, and suggests its usefulness for illuminating engineers, school inspectors, opticians, and others.

New Books.

Messrs. Cassell & Co., Ltd., (La Belle Sauvage, London, E.C.), inform us that they are publishing vol. i. of a new edition of 'Electricity in the Service of Man,' by R. Mullineux Walmsley, D.Sc., and also a new edition of 'Practical Electricity,' by the late Prof. W. E. Ayrton, revised and largely rewritten by Prof. T. Mather of the Central Technical College.

* *Illum. Eng.* Lond. vol. iii. Nov., 1910., p. 655.

Some Publications Received.

Bulletin of the Bureau of Standards, Washington, U. S.A.—This number (February, 1911) contains a detailed account of 'A New Form of Direct-Reading Candle-Power Scale' and a 'Recording Device for use on Precision Photometers,' by G. W. Middlekauff. It will be recalled that the principle of the recording arrangement has been previously referred to in this Journal.*

The Physical Review, April, 1911.—O. M. Stewart contributes an article on the 'Electromagnetic Emission Theory of Light,' and among the proceedings of the American Physical Society we notice an abstract of a paper by Dr. H. E. Ives comparing the 'Equality of Brightness and Flicker Photometers' in their application to heterochromatic photometry. The chief points of this paper were summarized in a report of the Fourth Annual Convention of the Illuminating Engineering Society (U.S.A.) which appeared in our issue for February, 1911, p. 77.

Transactions of the Illuminating Engineering Society (U.S.A.), April, 1911.—In a paper on 'Energy Standards of Luminous Intensity,' Dr. Ives discusses, theoretically and practically, the use of a standard defined by the quantity of energy radiated in a given time. J. C. Pole gives details of some experimental results he has obtained in the 'Photometry of Mercury Vapour Lamps,' and there are also some notes on 'Sign Lighting' by O. P. Anderson.

Elektrische Beleuchtung von Kaischuppen. By Adolf Boje. Reprinted from the *Elektrotechnische Zeitschrift.*—An illustrated article dealing with various problems in connexion with the lighting of docks and quays.

The Silver Disc Pyrheliometer. By C. G. Abbot.—An account of experimental work carried out by the Director of the Astrophysical Observatory of the Smithsonian Institution.

Proceedings of the American Gas Institute, 1910.—A complete report of the proceedings at the Fifth Annual Meeting, held in New York City, October, 1910.

Among other publications we have also to acknowledge the receipt of the following: *The Proceedings of the Physical Society of London, The Journal of the Institution of Electrical Engineers, The Transactions of the South African Institute of Electrical Engineers, The Proceedings of the Iron and Steel Institute, The Journal of the Royal Society of Arts, The Journal of the Society of Architects, The Journal of the Royal Sanitary Institute, The Journal of the Western Society of Engineers, Zeitschrift für wissenschaftliche Photographie Photophysik und Photochemie, Sitzungsberichte der Königlich Bayerischen Akademie der Wissenschaften.*

* *Illum. Eng.*, London vol. iii., Sept., 1910, p. 581.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

A NUMBER of exceptionally interesting contributions have appeared in the United States, especially in the April number of the *Transactions* of the American Illuminating Engineering Society. H. E. IVES (*T.I.E.S.*, April) suggests **A Monochromatic Standard of Light** based on measurement of radiation. It has been suggested that a white light standard, composed of red, green, and blue light of certain wave-lengths, might be tried, but the author shows that the practical difficulties are considerable. He finally suggests that the best method would be to adopt a greenish light of a single wave-length, viz., 0·546μ, which is the quality of radiation to which the eye is most sensitive. By the use of suitable screens monochromatic light of this wave-length can be easily isolated from the spectrum of the Quartz tube mercury lamp. The radiation can be measured with sufficient exactitude, but there are the usual difficulties of colour photometry. An article by the same author and M. LUCKIESH deals with the **Production of Artificial Daylight** by the use of certain screens with the Tungsten lamp ; the loss of energy is naturally considerable, but the resemblance to the spectrum of daylight is said to be close (*Elec. World*, N.Y., May 4th).

L. BELL in the same journal (May 11th) draws attention to the connexion between the chromatic aberration of the eye and **Acuteness of Vision by Coloured Light**; the best definition can be got by monochromatic rays. J. R. CRAVATH (*Elec. World*, May 11th) discusses the **Calculation of Illumination** in a room, bearing in view the reflective power of surroundings. He gives a table showing that the percentage of the total flux of light sent down on the working plane is usually about 30 to 35 per cent. He also enters into the relative merits of direct and indirect lighting, and points out the effect of irregularity or shininess of the ceiling.

E. S. SIMONS (*T.I.E.S.*, April) discusses the relative merits of daylight and several artificial illuminants in **Making Cinematograph Films.** He describes a large mercury vapour lamp installation, and points out that the steadiness of artificial lighting is often a great advantage.

Among other articles of a more photometrical character we may note that of J. G. POLE (*T.I.E.S.*, April) on the **Photometry of Mercury Vapour Lamps.** The paper also contains a discussion of the flux of light from line sources : the surprising result is arrived at that in some cases the apparent calculated flux of light would vary according to the nature of the enclosing surface assumed. In Great Britain A. P. TROTTER (*Electrician*, May 19th) discusses the **Nomenclature of Primary and Secondary Sources** of illumination, dealing specially with the recent paper by Haydn T. Harrison before the Illuminating Engineering Society (London).

F. STEINDL (*Elek. u. Masch.*, April 2nd) deals with two simple problems in illumination. The first of these is the well-known calculation of horizontal illumination from a source at a prescribed height ; the second is a new method of calculating mean spherical candle-power.

Other papers of a more general character read in Great Britain include those of L. GASTER and F. J. HAWKINS. The former, in a lecture at the Exhibition of Applied Chemistry, London, dealt with the importance of good illumination to the chemist. An account was given of the part played by the chemist in the invention of artificial illuminants. It was pointed out that there are several problems to be faced in the lighting of chemical works resulting from the presence of fumes, steam-laden atmosphere, &c., and that some knowledge of chemistry on the part of the lighting expert is essential. The paper by F. J. HAWKINS read before the Junior Institution of Engineers on May 10th was of a general character. Progress in gas and electric lighting was briefly summarized and some remarks made on such subjects as street and indoor

lighting and the best means of avoiding glare.

There have also been several papers dealing with interesting special applications of illumination. *The Photographic Journal* for April contains the paper read by J. S. Dow and V. H. MACKINNEY on the **Measurement of Surface Brightness and its Application to Photography.** It is suggested that in judging exposure valuable information can be secured by measuring the actual brightness in foot-candles of objects in the field of view, and this method is found to be specially serviceable in taking photographs of artificially lighted interiors. A recent number of *Knowledge* refers to the use of phosphorescent bacteria in photography.

It is also to be noted that several articles on illumination have appeared in journals which do not usually make a speciality of this subject. For example, in *The Railway Gazette*, May 5th, there is a considerable space devoted to **Railway Lighting** in general, and such problems as the best method of illuminating carriages and repair shops, &c. *The Windsor Magazine* for May contains an article by Sir James Crichton Browne, in which stress is laid on the connexion between **General Health and Light,** and a number of curious facts are given regarding its effect on the skin, &c. *The Nineteenth Century* also contains a readable article by Bram Stoker on **Irving and Stage Lighting.** It appears that Irving was was one of the earliest originators of the use of coloured light on the stage for scenic display, and that he used to supervise these conditions personally, even holding special "lighting rehearsals" for the purpose.

GAS, ELECTRIC LIGHTING, &c.

THERE have been comparatively few contributions dealing with special developments in gas and electric lighting, and these two sections are therefore dealt with together.

The series of articles by A. SCHEIBLE on **Electric Street Lighting** are continued in *The Electric Review and Western Electrician.* The articles are illustrated by views of street lamps in various towns showing the method of central suspension, &c., and special attention is now devoted to developments in flame arcs.

R. A. HOUSTOUN (*Electrician*, April 28th) gives results of some experiments on the **Efficiency of Glow Lamps.** The radiant efficiency of the carbon filament he gives as 2·9 per cent, and that of the tungsten filament as 7·5 per cent. The contribution by E. P. HYDE and others (*T.I.E.S.*, April) was formerly abstracted in *The Electrical World*, and has been referred to previously. An interesting point is the demonstration of a considerable loss in energy by cooling at the leading-in wires of glow-lamps. A recent number of *Lumière Électrique* draws attention to the beneficial use of condensers in parallel with small lamp transformers, in order to improve the power factor. An article in the *Journal für Gasbeleuchtung* sets out the relative cost of various high-power electric illuminants with different consumptions of energy. R. F. PIERCE (*Illum. Eng.*, N.Y., May) describes the **Quartz Tube Mercury Vapour Lamp.**

As regards gas lighting, we may note the article by BRENNECKE on **Distance Gas Lighting** (*J. f. G.*, May 13th). Considerable economies have been made, and it is pointed out that automatic control is also useful in enabling any defect in the mains to be readily detected and localized. E. MÜLLER describes a form of **Artificial Silk Mantle** (*Z.f.B.*, April 30th), and there are accounts of the gas lighting at the Festival of Empire and National Scottish exhibitions.

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ELECTRIC LIGHTING.

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GAS, OIL, ACETYLENE LIGHTING, &c.

Brennecke. Fernzündung der Strassenlaternen in Haspe (*J.f.G.*, May 13).

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L'Allumage et l'Extinction des Lanternes d'Exterieur—Becs Renversées (*Rev. des Eclairages*, April 30).
L'Éclairage à l'Acetylene dans les Mines Grisouteuses (*Rev. des Eclairages*, April 30).
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CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik u. Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
J. G. L.—*Journal of Gaslighting.*
T. I. E. S.—*Transactions of The Illuminating Engineering Society (United States).*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

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EDITORIAL.

Artificial Daylight.

THE contribution by Dr. H. E. Ives (commencing on page 394 in the present number) raises a point of considerable industrial importance, namely, the production of "artificial daylight." By this is meant the production of an artificial light closely resembling normal daylight in colour.

There are cases in which the mere production of light in sufficient quantity is not enough; the *quality* is also important, and unless one can secure the right kind of light work cannot proceed satisfactorily. This is especially true of the many varieties of business concerned with coloured materials —in fact, in all cases in which delicate colour-matching is essential. These goods, it must be remembered, are disposed of during the daytime, and the colours are judged on a daylight basis. It is a matter of common knowledge that many shades of colours are much distorted when viewed under ordinary artificial illuminants, and give rise to quite distinct effects.

Under these circumstances there are many cases in which operations must be suspended when daylight has failed, and the inconvenience of this during the winter months can be readily imagined. In work of this kind an artificial light which resembled daylight closely (even if comparatively inefficient as compared with ordinary illuminants) would often be of considerable service. There are, of course, some artificial illuminants which approach daylight closer than others. The Tungsten lamp is considered better than the carbon filament lamp in this respect, and the newer forms of incandescent mantles are likewise much superior to the earlier ones. The Moore tube carbon dioxide tube is stated to afford an exceedingly close resemblance to daylight, and appears to have been found of considerable service in silk mills &c., in the

United States. Many of these concerns, it is stated, can by its aid continue working during the evening when they would otherwise have been obliged to confine their operations to the daytime and to shut down as soon as twilight approached.

Attempts have also been made, by Dr. Ives, Mr. C. O. Bastian, and others, to secure an approximately white light by combinations of different sources; for example, by the use of light from the mercury vapour lamp and from tungsten or carbon filament lamps in suitable proportions. However, it is not always convenient to arrange for a special installation of this kind, and a simple means of adapting ordinary illuminants to colour-work would be very beneficial.

Another interesting method of obtaining white light consists in using rhodamine and similar dyes which fluoresce a red colour in the rays of the mercury vapour lamp. Reflectors coated with material of this kind have been used in combination with the Cooper Hewitt tube, and are said to have enabled an exceptionally "white" light to be obtained.

Some progress has been made in the direction of fitting arc lamps with suitable screens designed to modify the colour of the light in such a way as to resemble daylight. By this means a very fair resemblance to daylight is said to be secured, but naturally this entails a certain sacrifice in efficiency, occasioned by the absorption of lights of certain colours.

A promising scheme of this kind appears to have been devised by Dr. Ives and Mr. M. Luckiesh for use with the Tungsten lamp. This involves the use of a screen consisting in a combination of signal green and cobalt blue glasses, used in conjunction with an appropriate gelatine film. When this screen is placed in front of an ordinary Tungsten lamp, the transmitted light is said to be very similar to normal daylight. By testing the absorption of each of the component screens throughout the spectrum Dr. Ives shows that they allow some colours to pass, but weaken others to just the right degree to remove the differences between the Tungsten light and daylight. It should be understood that even daylight itself is not quite constant as far as colour is concerned. It varies from day to day, and with different climatic conditions, and it is, therefore, necessary to aim at producing what may be called "average daylight."

If several tungsten lamps are mounted in a suitable box, and their rays are allowed to pass through a window consisting of the screen referred to above, we obtain a convenient artificial "daylight window." This can be readily attached to the electric supply circuit, and is said to be very serviceable for colour-matching. The specific consumption is, of course, high—about 10-12 watts per candle—but it is pointed out that the first cost is low, and that in many cases the expense for current would be inconsiderable in comparison with the great advantage of being able to carry out successful colour-matching by artificial light.

This provides an excellent example of the application of scientific knowledge of illuminating engineering to industrial problems, and we shall watch the development of this work with considerable interest.

Illumination and Accidents in Factories.

A short time ago we referred to the important report issued by the Departmental Committee on the Prevention of Accidents, in which special stress was laid on the need for adequate illumination.* The evidence before this Commission is now available *in extenso*, and we give on pp. 401–404 a summary of a few of the most striking comments that were made. We have also just received the Report of H.M. Chief Inspector of Factories for 1910,

* *Illum. Eng.*, Lond., April, 1911, p. 193.

and we observe that the findings of the Commission as regards defective lighting receive confirmation, special emphasis being again placed on this matter. The Commission had evidently determined to take up this subject of good illumination as a special point, and questions were put to many of the witnesses with a view of ascertaining whether some general reference on the subject of lighting in the Factory Act would be beneficial.

In the evidence it was repeatedly remarked that dimly lighted passages were a danger, and especially so in cases where men had to carry heavy weights, molten metal, &c.; for if the illumination was insufficient, employees were very apt to stumble over obstructions or irregularities in the floor surface. Other witnesses pointed out the danger of work by a poor illumination in shipbuilding yards, on scaffolding, &c., and cases were described in which men had fallen, simply through inability to recognize a foothold and to see where they were going.

In the same way the tendency of bad illumination to strain the eyes and nerves and so lead to casualties was admitted. Inspectors frequently called attention to defects of this kind, and employers generally appreciated their suggestions.

One very striking point brought out by the evidence was the need for more perfect methods of classifying accidents. In several cases representatives of Federations of Employees expressed their conviction that accidents *were* often caused through poor lighting, but admitted that it was sometimes difficult to obtain reliable statistics on the subject because no adequate record was available discriminating between the causes of the accidents referred to. As we remarked when last dealing with this matter, the suggestions in this report seemed bound to meet with general approval. What is needed (and we have no doubt that steps in this direction are being taken) is for sufficient evidence to be collected by inspectors and others enabling us to trace the accidents due to bad lighting, and to ascertain which are the chief defects calling for remedy.

In studying such matters *actual measurements of illumination* seem very desirable, and it may be hoped that by this means the basis of a satisfactory general standard of illumination in factories will eventually be made clear.

This matter might be commended to the notice of insurance companies, which are directly concerned with the effect of lighting on accidents. It may be hoped that they will yield their aid in collecting statistics on the subject. A great stimulus to good lighting would also be given if companies would make a practice of making a reduction in premiums in the case of judiciously lighted premises. Special emphasis would naturally be placed upon the adequate lighting of dangerous machinery and the proper placing of lamps. This need not entail extra expenditure in energy: it is the correct position of lamps rather than the lavish display of light that is chiefly required.

In view of the clearly established connexion between bad lighting and the prevalence of accidents such a procedure would be quite natural, and, in fact, we are given to understand that it has already been followed by some companies. It may be pointed out that a similar course is taken in insuring against fire, it being recognized that concerns which install special fireproof flooring, &c., are entitled to special terms.

As a concluding word, reference might be made to the experience of the Fidelity and Casualty Co. of New York, which, after an exhaustive enquiry into the origin of casualties in factories, placed bad illumination *first* among the general causes of accidents.

The Value of Illuminating Engineering to the Gas Industry.

Among the valuable papers read at the Annual Meeting of the Illuminating Institution of Gas Engineers during the past month is that by Mr. S. B. Langlands, of Glasgow, on Public Lighting.

The paper, with which we mean to deal more fully in our next number, gave some very practical information about the public lighting in Glasgow, and the methods of supervising and securing prompt attendance to defective lamps and mantles. What, however, is specially gratifying is the appreciation by the author of the value of the Illuminating Engineering Society. Such a Society, he remarks, "should be hailed by all gas engineers as a possible source of great help..... Town planning is being discussed and advocated, garden cities are being laid out every day, and one wonders if the public lighting of these is receiving its due meed of attention .....Do gas engineers fully recognize the value of street lighting from an advertising point of view?"

There is, indeed, good work to be done by engineers interested in all methods of street lighting in promoting discussion of this subject and pointing out possibilities of improvement, both from the practical standpoint of providing illumination and from the decorative point of view. We hope that gas engineers will recognize and make the fullest use of the impartial platform of the Illuminating Engineering Society in impressing this point on public notice. We are glad to see that the value of the illuminating engineering movement is becoming more fully appreciated by the gas industry, and that it is already receiving from the members of the industry substantial and valued support.

Illumination and the Decorative Craftsman.

Recollection of Mr. Bassett Jones's article on 'The Lighting of the Allegheny County Soldiers' Memorial'* leads one to remark that there is also an immense field for co-operation between the engineer, the architect, and the decorator in interior lighting. Attention was called to this matter in the recent discussion at the Illuminating Engineering Society of the papers by Mr. Haydn Harrison and Mr. Waldram. It was pointed out that the lighting expert is often very much handicapped by want of knowledge as to the exact decorative scheme to be followed in a new interior. It often happens that the use of walls of a dark tint leads to results which are the reverse of satisfactory from the illuminating engineering standpoint, so that the lighting has to be adjusted and remodelled.

Here, therefore, is an opening for co-operation between the lighting expert and the decorative craftsman. In the case of buildings of architectural distinction it can safely be said that the latter would benefit considerably by taking counsel with the illuminating engineer. The lighting conditions are very readily prejudiced by want of care in the design of decoration. But the artistic appearance of a room may be entirely jeopardized if an incorrect system of lighting is employed. The solution, therefore, is for those interested in both aspects of interior illumination to consider such problems conjointly.

Lastly, it may be added that there is room for co-operation of this nature in the design of the actual lighting fixtures themselves. At present it is difficult to find fixtures which are reasonably cheap and in good taste and yet efficient from the illuminating engineering standpoint. The tendency has been to aim *either* at efficient or artistic pretensions, and we are still waiting for men who unite gifts in *both* directions. We trust that the Illuminating Engineering Society will be the means of bringing about an interchange of views between these experts and the lighting engineer.

LEON GASTER.

* *Illum. Eng.*, London, April-May, 1911.

Review of Contents of this Issue.

THE technical section (p. 389) opens with the first part of an article by DR. E. P. HYDE, F. E. CADY, and A. G. WORTHING on the **Energy Losses in Electric Incandescent Lamps**. The investigation described by the authors was carried out with a view to determining whether the loss of energy by conduction at the leading-in and supporting wires in incandescent lamps is really as small as has been generally assumed in the past. The article describes fully the method adopted for determining the radiated power and luminous flux of a unit length of filament. This consists in placing the filament to be examined in front of a bright background formed by an enlarged image of another one, the current through the latter being varied until the filament in front cannot be distinguished from the background. In this way interesting results have been obtained and recorded graphically.

Two notes follow, dealing respectively with the **Use of Condensers in Parallel with Transformers** for reducing no-load losses on lighting circuits, and the **Calorific Standard of Coal Gas.**

DR. H. E. IVES and M. LUCKIESH (p. 394) contribute an article on the **Subtractive Production of Artificial Daylight.** It is pointed out that if the excess of yellow and red radiation usually met with in artificial illuminants could be absorbed by the use of suitable media, the resultant light might be a fairly close approximation to daylight.

The authors discuss the characteristics which a white light should possess in order to be suitable for colour matching, and curves are given showing the relative intensities of the various spectral colours in average daylight, and the absorption that would be required to transform the light of a tungsten lamp into "daylight" is represented graphically. Finally, the article describes the application of these theoretical considerations by the authors in the production of a "daylight window" which, by its absorption of the excess of red rays, gives a very useful approximation to daylight.

Following this will be found an account of the development which has taken place in the application of **Acetylene Lighting to Buoys and Lightships.** The requirements of apparatus for marine lighting are briefly outlined, and the value of dissolved acetylene as satisfying these conditions is emphasized. A typical acetylene buoy is illustrated and described, and particulars are given of the action of the various accessory parts such as the flasher and the "sun" valve. Mention is made in conclusion of the low maintenance cost of these buoys, which is due in a large measure to the fact that they will work for a very long period without attention.

On p. 401 the **Influence of Illumination on Accidents** in the industrial world is dealt with. The article quotes several examples (taken from the Official Report of the Departmental Committee on Accidents) of accidents, fatal and otherwise, which could be directly attributed to deficient illumination. In some cases, shadows were responsible for persons stepping off platforms and falling; in other cases, the illumination was so low that objects which could not be discerned on the floor were tripped over. Reference is made to accidents caused by the explosion of defective naphtha lamps, and special attention is drawn to the need for better light in iron foundries, where the slipping of a man carrying a ladle of molten metal might be a serious matter. It is pointed out that further data are required showing the intensity of illumination required for different purposes and the chief defects to be remedied in industrial lighting.

The application of inverted arc lighting to the **Illumination of a Bakery** is next described (p. 405). The importance of artificial light in a building of this kind, where so much of the work is done during the night, is pointed out, and some photographs showing the uniformity of illumination obtained in this installation are reproduced.

On pp. 410–419 will be found a record of the replies which have been received from a large number of authorities in different parts of the world to the queries on the subject of a **Standard Specification for Street Lighting.** The views of DR. LOUIS BELL and MR. P. S. MILLAR in America, PROFS. BUNTE, DREHSCHMIDT, and TEICHMÜLLER, DR. L. BLOCH, and DR. MONASCH in Germany, and PROF. RUMI (Genoa), HERR K. SATORI (Austria), &c., are among those that have already been received. The queries to which these gentlemen have replied deal with such points as whether the energy consumed or the light provided should be specified, or both; how illumination should be measured; and whether there should be any test of the constancy of the light, &c. The chief points of agreement in the replies have been briefly summarized in the form of a table following this article.

A report of a paper recently delivered by MR. F. J. HAWKINS, entitled **Notes on Illumination by Gas and Electricity** follows (p. 420). The author emphasizes such points as the avoidance of glare and the suitable direction of lighting by the use of correct shades. In the discussion which follows, several speakers corroborate the statements made by the author with respect to glare and light distribution.

Under the title of **Illuminating Engineering and the Cinematograph,** a number of interesting questions are dealt with on page 421. A table is given of the cost when using several different illuminants, and in particular the cost of the arc lamp is discussed. A curve showing the variation of the current required with the area of the screen is reproduced, and it is pointed out that there is room for considerable improvement in the scientific distribution of light on the screen.

Following this are some **Notes on the Placing of Lamps,** in which several important requirements are insisted upon.

A lecture by MR. L. GASTER, dealing with **Illumination from the Standpoint of the Chemical Engineer,** is briefly summarized on p. 427. The part played by the chemist in the development of new methods of lighting is first outlined, and this is followed by a reference to the recent attempts to obtain an artificial daylight for colour matching. The lecturer concludes by emphasizing the special character of the conditions of lighting required in chemical works.

Some notes on the **Perception of Light and the Sense of Colour**, taken from two papers by DR. F. W. EDRIDGE-GREEN, will be found on p. 428. In the first of these papers the author urges the importance of discriminating between the power of distinguishing colour and the capacity to see light; it is difficult otherwise to explain the results obtained in testing colour-blind people. The second paper is concerned with an investigation of the visual purple, and a method of demonstrating its movements is described.

Among the **Short Notes on Illuminating Engineering** (p. 429) may be mentioned DECORATIVE LIGHTING IN SCHOOLS, with an illustration of the lighting of a school hall in Germany, and a reference to the use of MERCURY VAPOUR LAMPS IN A MOVING PICTURE STUDIO, where it is found that the best results can only be got by relying on artificial illumination.

On p. 433 will be found the usual **Trade Notes,** followed by the **Review of the Technical Press.**

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A Study of the Energy Losses in Electric Incandescent Lamps.

By Edward P. Hyde, F. E. Cady, and A. G. Worthing.

I. Introduction.

In studying the radiating properties of matter it is frequently convenient, especially in the case of metals, to mount the material to be investigated in the form of a filament in an exhausted bulb, as in the ordinary incandescent electric lamp. This arrangement is particularly advantageous if the relation between the supplied power and the radiated power is known, since it is then possible to determine the radiation at any temperature, *i.e.*, at any voltage, by measuring the power supplied to the lamp.

The possible difference between the power in-put and that radiated by the filament will depend in general upon three factors: (1) the C^2R loss in the leading-in wires and joints; (2) the fraction of the supplied power that is dissipated by convection and conduction of heat by the gas enclosed in the bulb; and (3) the fraction dissipated by thermal conduction along the leading-in and supporting wires. There is no reason why the C^2R loss may not be made as small as desired. In ordinary commercial lamps it is less than 1 per cent—more usually of the order of magnitude of 0·1 per cent or 0·2 per cent.

Although the loss by gas conduction and convection is quite large if the bulb is not well exhausted, amounting in extreme cases to several hundred per cent, it is negligibly small when the vacuum is of the order of magnitude of 0·001 or 0·002 mm. of mercury, or less. The relation between the pressure of air in the bulb and the power required to maintain a filament temperature of approximately 1,400° C. is shown in Fig. 1 for the case of a platinum filament 15 cm. long, and 0·1 mm. diameter, mounted in a pear-shaped bulb of 8 cm. maximum diameter and 13 cm. length. The magnitude of this loss will depend, of course, upon the size of the bulb, the nature of the enclosed gas, the size and material of the filament, and the temperature of operation. The higher the temperature, the smaller is the relative loss. But in all ordinary cases, as in commercial lamps, the conditions are such that the loss due to the conduction and convection by the enclosed gas is negligibly small.

With regard to the losses by conduction away of the energy of the filament by the leading-in and supporting wires, there has been much discussion. In a previous investigation* by one of the authors *et al.* of the selectivity in the radiation of certain metals, it was assumed that this loss by conduction away of heat is small. This assumption was based partly on a casual inspection of the filaments when incandescent and partly on the experience of lamp makers, who find that practically the same data may be used in computing the dimensions of lamps of different voltages and wattages within reasonable limits.

* *Elec. World* 53, p. 439; 1909. *Trans.* Illum. Eng. Soc., 4, p. 334; 1909. *Jour. Frank. Inst.* 169, p. 439; 1910.

The same assumption has been made by Drysdale* and Fery†. On the other hand, direct measurements by Helmholtz‡, Lux§ and Leimbach‖, of the total radiation have indicated large differences between the power supplied to the lamp and that radiated by it. The results of Leimbach, whose work is the most recent and most complete on the subject, will serve as an illustration. He finds for the "relative radiating power" (ratio of radiated to supplied power) of the various carbon and metal-filament lamps values ranging from 61·9 per cent to 80·5 per cent. Thus in the most favourable case approximately 20 per cent of the supplied power is not radiated to the measuring bolometer, and on the average the loss amounts to about 30 per cent. Moreover, it would seem that this loss is ascribed principally, though not entirely, to the heat conduction at the leading-in and supporting wires. At least, differences of 15 per cent (as between the A.E.G. 228-volt tungsten and the "Sirius"–Kolloid 220-volt tungsten lamp) are ascribed to differences in supports which would seem to indicate that the total loss in every case is due primarily to heat conduction at the leading-in and supporting wires.

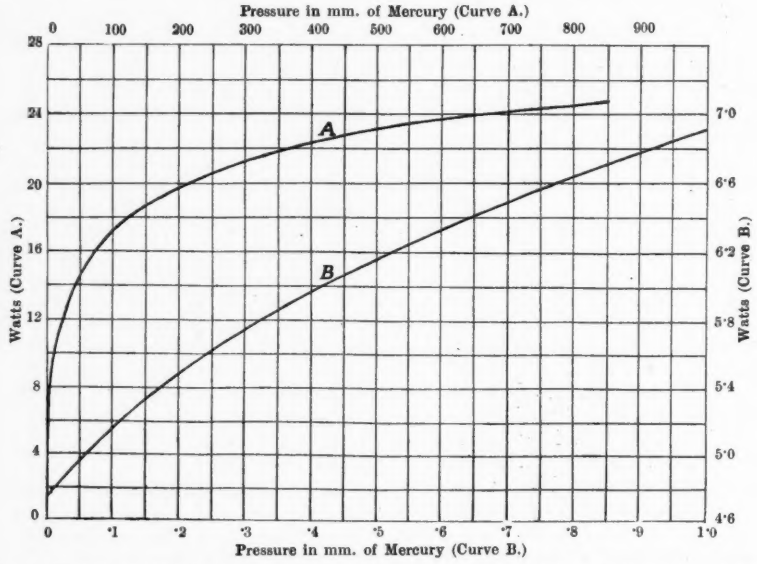


FIG. 1.—Variation with air pressure of the watts required to maintain a platinum filament at a constant temperature (that of a colour match with a black body at 1690° abs.).

II. GENERAL METHOD.

The discrepancy between the large losses found by direct experiment, and the relatively small ones which general considerations and the experience of manufacturers would indicate, suggested the importance of further investigation of the subject, particularly as the present authors' conclusions regarding selectivity in the radiation of various substances rest on the assumption that the ratio of luminous flux to total power radiated in the case of an ordinary

* *Jour. de Phys.* (4), 7, p. 872; 1908. Lond. *Illum. Eng.*, 1, p. 642; 1908.

† *Bul. Soc. Int. des Elec.* (2), 9, p. 673; 1909.

‡ *Beiblaetter*, 14, p. 589; 1890.

§ Lond. *Illum. Eng.*, 1, p. 98; 1908.

‖ *Zs. f. wiss. Phot.*, 8, p. 333; 1910.

incandescent lamp is approximately equal to the lumens per supplied watt, *i.e.*, that the losses by thermal conduction are comparatively small.

In approaching the problem it is well to discriminate between the energy radiated by the filament and the energy radiated by the lamp as a whole. These two quantities of radiation may differ, and the quality of the radiation from the filament may be different from that from the lamp as a whole. The glass bulb absorbs some energy of every wave-length, but the absorption in the visible spectrum is quite small. Beyond 2·5 μ in the infra-red, glass begins to exhibit strong absorption. The energy absorbed by the glass is dissipated again, partly by radiation of very long wave-lengths and partly by conduction and convection by the air. Moreover, in the case of old lamps there is a deposit formed on the inner side of the bulb, and this deposit absorbs strongly in the visible, as well as in the infra-red region of the spectrum. Drysdale* by a calorimetric method measured the energy lost by convection from the bulb in a particular lamp and found the loss to be of the order of magnitude of 2 or 3 per cent.

Some few observations were made on the absorption in the visible spectrum of lamp bulbs, including both new bulbs and those on which there was a marked deposit. In the case of new lamps the decrease in luminous flux owing to absorption by the bulb amounts to only 2 or 3 per cent. Bulbs of lamps which had burned to approximately one-quarter of their normal lives showed absorptions of the order of magnitude of 5 per cent or 6 per cent differing, of course, from lamp to lamp. Very old lamps which had burned out were so darkened with deposit that absorptions as large as 25 per cent were observed. It is evident, therefore, that for lamps which have been seasoned, but not burned to any great extent, the absorption of visible radiation need not exceed 5 per cent, and that the relative differences between lamps of different types should be much smaller than 5 per cent.

* *Loc. cit.*

In the methods employed by Helmholtz, Lux, and Leimbach the total radiation from the lamp was measured; but since the large observed differences between the power supplied and that radiated was attributed by Leimbach to a great extent to the thermal conduction losses at the supports, it seeemed advisable to apply some new method which would give the difference between the power supplied to the *filament* and that radiated by the *filament*. This difference would unquestionably be due only to thermal conduction losses. In the case of moderately new lamps, in which there is no marked deposit on the bulb, this difference gives more nearly the real error which results from the assumption that the lumens per applied watt is the same as the lumens per watt radiated by the filament. It is, therefore, the more significant error in the methods employed by one of the authors *et al.* in the study of the radiating properties of metals.

FIG. 2.—Diagrammatic Sketch of Apparatus.

The method employed in the present investigation consists, in brief, in determining the power supplied to every millimeter length of filament, the power radiated by every element of filament, and the luminous value of the radiation from every element of filament. These data give at once the difference between the power supplied and that radiated by the whole filament, and hence the loss by thermal conduction. The data also gives the difference between the actual efficiency of the filament and the efficiency it would have if there were no conduction losses.

The casual inspection of a lamp in operation, particularly of a metal-filament lamp, shows the cooling effect of the leading-in and supporting wires. It is quite easy to measure the supplied power, the radiated power, and the luminous flux of a unit length of filament at any point, without making any temperature measurements or any assumptions whatever regarding the

temperature. The method employed, which is an application of the principle of the Holborn-Kurlbaum optical pyrometer, is as follows :—

An image of a part of the filament of a large-filament lamp A (Fig. 2) is projected on an enlarged scale by means of the lens B on the plane of the filament of the lamp C under investigation. The telescope D is focussed on the filament of lamp C so that the filament of C is seen in the telescope against a bright background consisting of the enlarged image of the filament A, which is also in the focus of telescope D. By varying the current in the auxiliary lamp A the filament of C can be made to disappear against the background. The disappearance can be secured more accurately if monochromatic light is used, and to this end a strip of red glass is placed over the eye-piece E of the telescope.

The test lamp C is mounted on an adjustable support. By raising or lowering lamp C, different parts of its filament can be seen against the bright image of filament A, as a background. As successive portions of the filament of lamp C are seen against the image of A, the currents in A corresponding to a disappearance are determined. In this way the whole filament is explored, measurements being made as close to the leading-in and anchoring wires as the reduced luminosity of those cooled portions will permit.

The results for one of four filaments of a 110-volt 60-watt tungsten lamp, taken as an illustration, are plotted in Fig. 3, curve "A." The abcissæ are distances along the filament from a leading-in wire to successive points on the filament up to the end of the filament where it is welded to a support at the base-end of the mount. The ordinates are the values of the current in the background corresponding to a disappearance of the various portions of the test filament, as seen in the telescope. The filament was 160 mm. long, and intermediate between the two ends, at 80 mm. from the leading-in wire, the effect of an anchoring wire of the ordinary loop-form is seen.* Near the leading-in wire the filament is cooled by thermal conduction, and so the

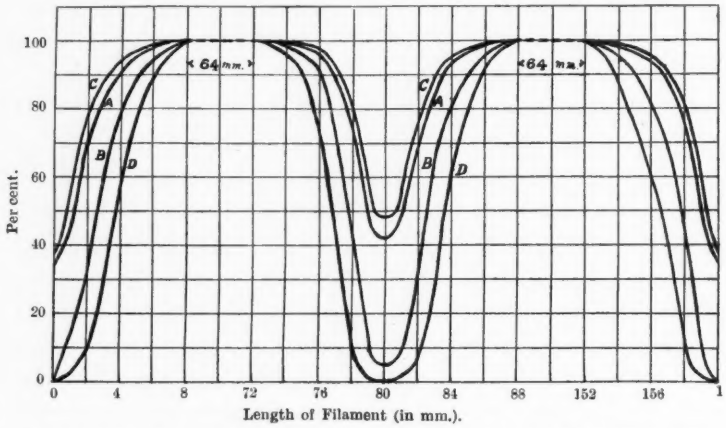


FIG. 3.—Sample Curves, showing conduction losses for a 60 watt, 110 volt Mazda lamp.

Curve A = Relative current values of background lamp.
Curve B = Relative output distribution.
Curve C = Relative input distribution.
Curve D = Relative distribution of light flux.

* In Fig. 3, as in the following figures, it should be kept in mind that a considerable portion of each curve corresponding to the portion of the filament glowing with maximum brightness has been omitted.

emission is decreased. It is, therefore, necessary to reduce the current in the background lamp in order that the two may have the same apparent emission, *i.e.*, in order that there may be a disappearance as seen in red light through the telescope. In the neighbourhood of the anchoring wire the cooling effect is again noticed, though the magnitude of the cooling here is not as great as at the leading-in or other welded joints. In fact it is frequently difficult to measure the cooling effect at the loose anchors because the contact between the filament and the anchor is variable; at one moment there is apparently no cooling whatever, and a moment later a fairly good contact is established. By taking all four of the filaments between successive welded joints in a tungsten lamp an average result is obtained. In the tantalum lamp there are only two rigid joints, at the leading-in wires, and 21 loose anchors. By taking a large number of the anchors, however, it is possible to average up with fair accuracy the uncertainty due to the variable contacts.

Data similar to those represented in Fig. 3, curve "A," for one filament of a 25-watt tungsten lamp were obtained for a number of lamps of different types. In every case, when the lamp was operating at normal voltage the cooling effect was found to extend only a short distance from the contact points as exhibited by the flatness of the current curve throughout the greater part of its length. This fact, that the cooling effect is confined to the parts of the filament quite near the supports, renders available a simple method of determining with a fairly high accuracy from the observed curve of background current, as in Fig. 3, curve "A," the losses in watts and in efficiency due to the conduction away of heat at the supports.

(*To be continued*).

The Use of Condensers with Small Transformers on Lighting Circuits.

The introduction of small transformers, for obtaining the low voltages most suitable for metal filament lamps, has recently attracted much attention. But the efficiency is only high when the transformer is fully loaded. The problem remains of improving the power factor of installations employing a number of such transformers. At some times in the day these will be lightly loaded, so that the power factor will be inconveniently low and the loss of energy from the "no load current" considerable.

According to a note in *La Lumière Electrique*, the use of a condenser, in parallel with the transformer, has been applied by M. Hegner with practical success, and his system is stated to have given excellent results when tested at the Laboratoire Central de l'Électricité. With a condenser of 1·37 microfarads capacity it was possible to obtain a power factor as high as 0·9 with the transformer working on no load, as compared with 0·67 under ordinary conditions.

The Calorific Standard of Coal Gas.

In view of the reduction of the standard of illuminating power from 18 candles to 14 candles which has recently been approved by the Board of Trade at Preston, it is interesting to note some comments of the *Journal of Gas Lighting* on the vexed question of the Calorific Power Standard.

It is pointed out that it would not do for the standard to be fixed too high, for in this case some of the economies possible in producing gas which no longer requires benzol enrichment would be missed. M. Grebel, writing in the *Journal de l'Éclairage au Gaz*, has recommended a minimum net calorific power which is equivalent to 500 B. Th. U. This is considerably higher than British practice, *e.g.*, the standard of the Gas Light and Coke Company works out at 450 B. Th. U. net, but even this latter figure might, it is suggested, lead to inconvenient restrictions in producing gas for incandescent lighting.

On the other hand, the interests of users of gas for purposes other than incandescent lighting, must be considered.

Subtractive Production of Artificial Daylight.

By Herbert E. Ives and M. Luckiesh.

Most forms of artificial light are very different in colour from daylight. The common illuminants, such as gas flames and incandescent electric lamps, have the colour of incandescent solids at comparatively low temperatures, such as 2,000° C, while the colour of daylight corresponds more nearly to an incandescent solid at a much higher temperature, about 5,500° C. This means that, when giving the same measured illumination, our common illuminants as compared with daylight are deficient in blue light and have an excess of red light. This difference is really very large, and were it not met by a comparatively great power of adaptation in the eye, would seriously interfere with our comfort under artificial illumination. In Fig. 4 are given the relative intensities of the various spectral colours in an average daylight (curve *a*) and in the tungsten lamp (one of the whitest of artificial lights) when the two are giving approximately the same illumination. Whatever disturbance of vision this change from daylight colour may or may not cause, there is one practical necessity which even the adaptive power of the eye cannot entirely meet. That is the selection and matching of colours in materials such as paper, cloth, or ribbon. If colour combinations are to be used in daylight they cannot be made by artificial light, for matches and colour harmonies under the one light are not so under the other. Purples (red plus blue), for instance, because of the deficiency of artificial lights in blue, appear under them of a red tinge; blues look very dark or black, while reds are disproportionately bright as judged by their daylight values.

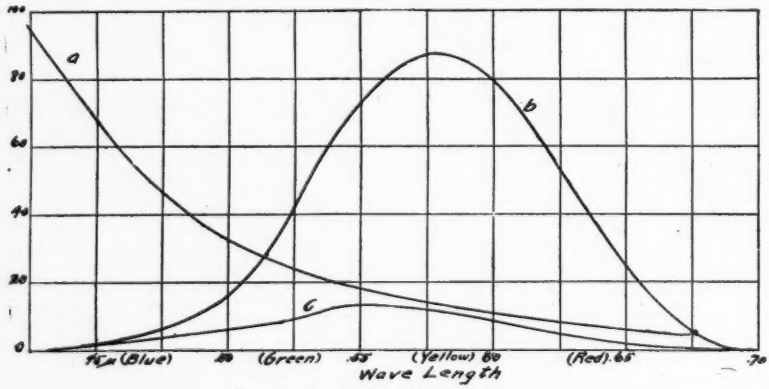


Fig. 1.—Spectral Luminosity Curves.

Curve *a* = Ideal Absorbing Medium.
Curve *b* = Luminosity Curve of Tungsten Lamp.
Curve *c* = " " " " " through Ideal Absorbing Medium.

For certain technical purposes it consequently becomes of importance to secure artificial daylight for use in the absence of the natural article. One way of doing this is by the use of absorbing media over the artificial lights to absorb the excess of yellow and red radiation. This may be termed the subtractive method, to distinguish it

from the additive method; the latter is illustrated by the combination of a mercury arc with tungsten lamps. The nature of the absorption and the method of calculating the resultant loss in efficiency in this subtractive method have been treated elsewhere by one of the present writers. From that investigation it appears that the transmission of the absorbing screen should be the reciprocal of the relative brightness of the illuminant and daylight at each part of the spectrum. Since that work was done, more extensive data have been obtained on the colour value of daylight (Fig. 4), and on this basis the necessary absorbing medium to transform tungsten lamplight into "daylight" has been calculated. It should have the transmission through the spectrum shown in Fig. 1, curve *a*. Curve *b* shows the luminosity or brightness distribution in the tungsten lamp; curve *c*, the same after transmission through the medium *a*. Comparison of the areas of *b* and *c* shows the resultant candlepower to be 15 per cent of the original. This is the "daylight efficiency" of the tungsten lamp, and corresponds to about 10 watts per mean spherical candle.

The present paper is an account of an attempt to obtain coloured glasses and other media approximating the curve *a*. Before describing the results of this work, a few words are necessary as to the degree of exactness with which the requirements must be met; for it must be understood at once that none of the usual absorbing media may be expected to conform exactly in transmission to the curve *a*. In the first place attention must be called to the variable character of "daylight." Varying as it does from the deep blue of the clear sky, through the clear white of the noonday sun to the yellow of late afternoon sun and clouds, daylight is far from a definite thing. For purposes of specification our average may be chosen more or less arbitrarily: the curves of Fig. 1 represent what there is good reason for believing to be a fair average. When the problem is that of producing artificial daylight, the variability of natural daylight gives us a certain latitude. We may be satisfied to strike *a daylight* with the prospect that it will be satisfactory to the eye. The variation in daylight is of a perfectly definite character; it consists in a very uniform increase or decrease in the intensity of the spectrum toward one end or toward the other. An increase as we go toward the blue end corresponds to blue sky; toward the red end, to low sun. As long, therefore, as the difference between the artificial daylight and the average daylight (given in Fig. 4) is of the nature of a progressive increase in intensity toward the blue end of the spectrum or vice versa, the difference not being large, it will merely mean approximation to a slightly different quality of daylight and need not be serious.

Two physiological peculiarities of the eye excuse us from the practically impossible task of exactly reproducing the composition of daylight. First comes adaptation. If there is presented to the eye an illumination which approaches white in character, the eye will quickly grow accustomed to it, and will form a colour scale to fit, just as the man in a wind will incline his body so as to preserve equilibrium. But while adaptation is of great assistance, it cannot do everything, and if a radiation is missing, or nearly so, the eye cannot supply it entirely. Adaptation will not make it possible for the eye to distinguish purple from red under candlelight, but if a light is nine-tenths of the way from candlelight toward white, and of proper character, the eye may be depended upon to do the rest. The second physiological factor is the possibility of subjective or physiological mixture. Thus a white light can be matched by mixing merely red, green, and blue, or by mixing yellow and blue. Consequently an artificial white might be made whose spectrum had several humps or depressions, yet the total light might be a good white. If, then, it be found impossible to avoid having certain bands of excess spectral transmission in the absorbing medium, it is often possible to distribute these so as to produce a white.

What characteristics should a "white" light have to make it suitable for colour matching? While a white may be made in which certain colours are entirely missing, as stated above, such a light would be unsuitable for colour matching; the fewer the colours present the less suitable would the light be. A two-colour white (yellow-blue) would not illuminate a true red, and that colour would appear black—a case corresponding very nearly to the mercury vapour lamp. For the ideal white all the colours should be present, and in the proportions of daylight. A study of the colours of most natural objects, however, reveals the fact that those colours are very rarely pure isolated spectral hues, but rather long diffuse bands of spectral light. A pure yellow is practically never met with in nature; in fact, our yellow fabrics are all merely white minus blue and some green. As a consequence, a white light consisting of isolated colours may yet possess enough colours to have very little disturbing effect on ordinary coloured objects. Just how many spectral colours should be present is not a matter easily capable of exact statement, but certainly there should at least be the three—red, green, and blue—and preferably more.

In the continuation of this article it will be shown how we may apply these general considerations, plus some experience and experiment, to the production of "artificial daylight."

The following are the requirements to be met in producing artificial daylight:—

1. The total light should appear white; that is, should have the integral colour of such a spectral distribution as Fig. 4 indicates, or should vary from it only by being slightly bluer or redder in the manner that daylight varies.

2. All the spectral colours should be present, but if gaps or irregularities exist in the spectrum the three principal colours—red, green, and blue—are necessary. Additional colours in equal or nearly equal intensity will improve the colour-matching performance of the light.

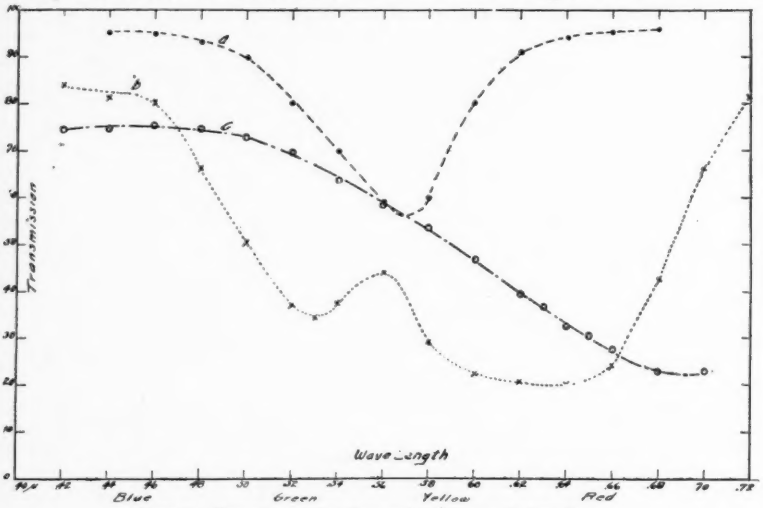


FIG. 2.—Experimentally Determined Transmission Curves.

These requirements fall far short of being exact specifications, but at present it is difficult to see how the various factors to be considered can be reduced to more exact terms. A rather large experience factor has of necessity been introduced in studying the problem. In the work which follows, the deviations allowed from the desired character are justified, and under the cir-

cumstances can only be justified by the experience of the writers as to the actual permissible amount of deviation from the conditions outlined above.

Some sort of blue glass or other medium is called for. Coloured glass is preferable to dyed films or solutions of coloured material because of its glass revealed two shades which might be used—ordinary pot blue, or cobalt blue, and signal green. The first alone transmits blue, an isolated spectral band of yellowish green, and the deep red. Used alone over a tungsten lamp it gives a purple light, because of the transmitted red. Signal green alone makes the light too green, but it

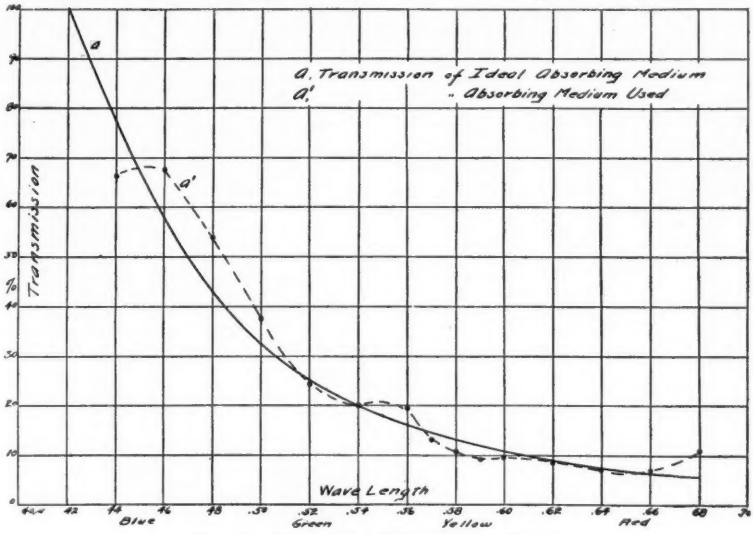


FIG. 3.—Comparison of Transmission Curves.

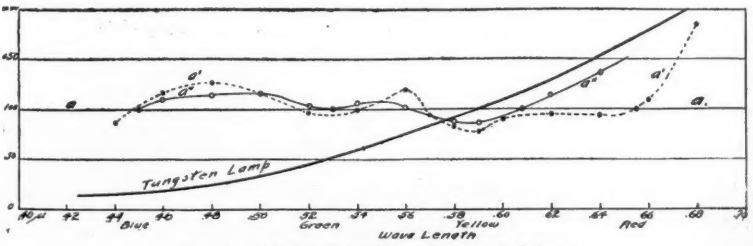


FIG. 4.—Relative Intensities of Spectral Colours.
Curve a for Average Daylight.
Curve a' for Combination of Commercial Glasses.
Curve a'' for Combination of Experimental Glasses.

practicability in handling and in permanence. The more diffuse and gradual absorptions of metallic salts are capable of incorporation in glass, and it is these rather than the narrow absorptions of most dyes that are called for in this problem. A study of a large selection of samples of coloured reduces the red that the cobalt blue transmits. A combination of the two appeared promising. Wedges of these glasses were ground and measured for transmission at various thicknesses on the spectrophotometer. From these measurements a combination of the two glasses was chosen

which approximates to the curve desired. A grave defect of this combination is the pronounced band of yellow-green transmission of the cobalt. In order to reduce this recourse was had to dyes. A peculiarity of the ordinary dyes is that their absorptions are very narrow and abrupt, so that they are not suited to securing the gradual absorption called for by Fig. 1. For the purpose of decreasing the transmission in a narrow spectral region, however, dyes are good. A dye—rozazeine—was found by trial which has an absorption band so situated as to cover very well the undesirable yellow-green band of the cobalt glass. stock thicknesses and depths conforming closely to the depth of colour chosen from study of the wedges. Fortunately two of the standard glasses carried by one of the large glass companies were quite near the desired character. The spectrophotometrically determined transmission curves of these, and of the dye in the depth used, are given in Fig. 2. Fig. 3 shows the transmission of the combination, compared with the theoretical one, while Fig. 4 shows the spectrophotometric curve of this artificial daylight in terms of the average daylight used as standard. The full line a'' is the combination obtained by study of the wedges of

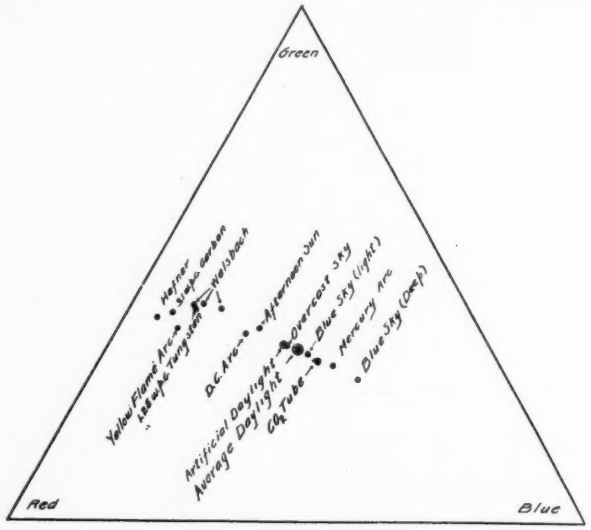


FIG. 5.—Colour Triangle.

With these two glasses plus a gelatine film flowed upon one of them, and containing a specified amount of dye, an absorbing combination is obtained which produces with a tungsten lamp a very satisfactory approach to "daylight." In the spectrum the total light is "white." No gaps and no bad depressions or humps exist, and the three elevations are in red, green, and blue. In short the conditions outlined above are approximated.

The next question which arose was whether glasses could be obtained in cobalt and signal green, the dotted line a' that of the glasses found upon the market. The latter glasses are of slightly different character from the cobalt and signal green, and give in some respects a better combination. Probably starting with these as a basis, it would be possible for a skilled glass worker to produce glasses even better, to combine these two in one, and perhaps even find a glass substitute for the dyed film. The latter would be especially desirable, as rozazeine, like many similar dyes, is not perfectly permanent.

With these glasses a "daylight window" has recently been constructed for the purpose of demonstrating the principle in a lecture on "artificial daylight." This consists of a tin box 16 in. by 12 in. by 20 in. holding six 60 watt frosted-tip tungsten lamps. The bottom of the box (16 in. by 20 in.) consists of the two glasses, one coated with the gelatine film containing the dye, the other a rough glass acting as a diffuser. The whole box rests upon legs 15 in. high. The surface to be illuminated is placed beneath where an illumination of about 30 foot-candles is obtained—ample for purposes of colour matching. The colour of this window has been measured on an Ives colorimeter, in terms of the average daylight which was determined by one of the present writers with that instrument. The readings—average daylight being equal parts red, green, and blue—were

Red	Green	Blue
100	85·4	75·8

These have been reduced to colour sensation values by the method used in a former paper. The sensation values, expressed so that their sum is unity, are

Red S	Green S	Blue S
35·5	34·0	30·5

These are plotted in a colour triangle, Fig. 5, along with several other illuminants. The centre of this triangle is "average daylight," the corners are pure red, green, and blue sensations, the distance of a colour from the centre is a measure of its deviation from average daylight. On this scale of measurement and scheme of representation this particular artificial daylight is nearer the average daylight striven for than is any other artificial illuminant.

The window made up has proved extremely satisfactory on test. The light appears "white," and all colours assume their daylight appearance under it. It has been temporarily used as a desk light, and the soft white colour has proved very pleasing. It constitutes a very satisfactory demonstration of the possibility of producing daylight by the subtractive method. The efficiency is of course not high, being 10–12 watts per candle. On the other hand, the first cost is extremely low. Such a window may be used on an ordinary lighting circuit, and its component parts are all easily renewed.

Acetylene Lighting for Buoys and Lightships.

The illustration on the next page is taken from a paper by J. Pattison, presented at the Convention of the International Acetylene Association at Chicago, 1910, in which the author deals with the development of acetylene lighting for buoys, lightships, &c.

Some of the essential requirements of apparatus for marine lighting referred to by the author, such as automatic operation for a definite predetermined period, reliability under extremes of temperature, low cost of maintenance, &c., have been previously dealt with in this journal. In tracing the recent developments in the lighting of buoys and beacons, the author lays stress on the value of dissolved acetylene as satisfying the above conditions.

The apparatus shown in the illustration is a typical buoy fitted for use with dissolved acetylene. It can be left alone for long periods without an attendant, the lighting up and extinction being automatic. The complete equipment consists of the gas storage cylinder, the governor, the flasher, and, in most cases, the "sun" valve. The governor regulates and maintains constant the pressure of gas arriving at the flasher; the flasher is a device for automatically lighting and extinguishing the flame; and the "sun" valve, working on the principle of expansion by light, automatically opens the main supply at night and closes it at sunrise.

The action of the flasher is as follows: a small quantity of gas is admitted to the burner by a valve which is then

automatically closed. As soon as this quantity of gas has been burnt, with the production of a momentary flash, the inlet valve is again opened, and the operation repeated. It is found that this arrangement is reliable so long as the acetylene supplied to it is absolutely dry and pure. By actuating the flame for alternate short periods of light and darkness, a considerable saving of gas

can be made, and yet the light is even more effective in attracting attention than a continuously burning flame would be. Thus the saving of gas from a light with a *bright* interval of 1/10 sec. and a dark interval of 9/10 sec. would be 90 per cent.

The "Aga" flasher is stated to be capable of producing 55,000 separate and distinct flashes (the duration of which can be cut down to 1/10 of a second or less) from one cubic foot of gas, whereas previously only 1,400 flashes could be secured.

The "sun" valve is actuated by means of copper rods, of which the central one is coated with lamp black and the outer ones coated with gold. All expand or contract for equal degrees of temperature, but only the inner one responds to *light*, and it is this that operates the main valve.

Buoys of this kind, it is stated, can readily be arranged to work without attention for a year, and have actually been in use for a considerably longer period. Their immunity from the extremes of temperature ordinarily met with is attested by their use in all parts of the world. Beacons have recently been established on the Yukon river, Alaska, which will be used for water navigation in the summer and ice navigation in the winter.

The extremely low maintenance cost is also mentioned as having contributed largely to the rapid development of acetylene lighting for marine purposes. A 300 candle-power light is said to cost for gas only about £12 per annum, and as no light keeper is required, the heavy item of expense in wages, &c. is entirely eliminated.

Yet another advantage claimed for acetylene buoys of this kind is the high intrinsic brilliancy of the flame, for it is on this, rather than on the total light, that the quality of being visible at a great distance is believed to depend.

The International Congress of Applied Electricity.

(Turin, Sept. 10th–17th, 1911).

THE International Congress of Applied Electricity will be held in Turin from Sept. 10th–17th, 1911, and a varied and interesting series of papers by authorities in various countries has been arranged. Among the subjects dealt with are: High Tension Transmission, Rotating Magnetic Fields, Electric Traction, Electric Tariffs, Electro-Chemistry, Accumulators, &c., and a paper will be presented by Mr. Leon Gaster entitled 'The International Outlook in Scientific Illumination.'

The subscription to the Congress will be 20*s.*, and those desiring to know particulars should apply to the Congresso di Elettricità, Politecnico, Torino, whence tickets may be obtained. Forms of application for membership can also be obtained from the Hon. Sec. of the Illuminating Engineering Society, Mr. Leon Gaster, 32, Victoria Street, London, S.W.

Illumination and Accidents in Factories.

SOME NOTES ON THE EVIDENCE BEFORE THE DEPARTMENTAL COMMITTEE ON ACCIDENTS IN FACTORIES AND WORKSHOPS.

IN the editorial in the April number of *The Illuminating Engineer* reference was made to the recently issued Report of the Departmental Committee on Accidents, in which lighting matters came in for a special share of attention. After quoting the views of a number of witnesses on this point the Report concluded by remarking that care must be exercised in seeking to establish any specific standard of illumination, "but," it was added, "even before such a standard can be arrived at, it is recommended that the inspectors should be given general statutory powers to require adequate lighting in all places where work is done, and in all places which are a source of danger by reason of insufficient lighting.

The complete account of the evidence before this Committee is now available, and it is interesting to see how entirely this bears out the conclusions in the report. The Committee had evidently determined to investigate the question of lighting with thoroughness.

MORE DEFINITE RECOMMENDATIONS ON FACTORY LIGHTING NEEDED.

The same questions were put to a large number of witnesses with the object of ascertaining whether it was agreed that more definite recommendations were required, and whether any proper standard existed. Inspectors of Factories, representatives of various associations of employees and manufacturers were unanimous as regards the first point, but it was naturally felt that more data were needed before a standard of illumination could be agreed upon.

In this connexion we may quote verbatim the remarks of an inspector, Miss E. Squire :—

"What do you say with regard to lighting and ventilation?" she was asked. The reply was :—

"We have no power to regulate lighting, though it is a very frequent cause of accidents and of grave danger, especially in the smaller printing works and hardware factories in the Midlands. Rooms are often very badly lighted where there is artificial light, and where there is overcrowding of machines the danger is very great. In cotton factories some of the rooms are dark. I was in a carding room yesterday where the cards were 10 in. to 6 in. apart. Although it was brilliant sunshine in the afternoon it was dark inside, and we had to pick our way carefully. We could not see our footing at all."

In answer to further questions she added that although inspectors could, by persuasion, get lighting done they had no statutory power to rely upon. On the other hand she doubted whether a standard of light in the same sense as a standard of temperature could be said to exist.

Evidence to the same effect was given by another inspector, Mr. G. Bellhouse, who remarked, "I have known cases of bad lighting, and I have known cases where, on the representation of the Inspectors, additional lighting has been provided"; this witness, however, also pointed out that there was no power under Factory Act to insist on efficient lighting, and thought that some general regulation in this direction was needed.

Mr. J. H. Crabtree, when asked "It is easy to fix a standard of temperature and air purity; is it practicable to have one of light?" answered that this was a scientific matter that could be worked out, and that there might be a photometric test.

An additional reason for regulations of this kind was suggested by Mr. J. H. Rogers, who explained that "it would be much more convenient and safer if there were a clause in the

Act referring to lighting, because then manufacturers who do not think of it would be much more likely to do so if the law required it."

Other witnesses gave evidence to the same effect and the general impression seemed to be that some more definite general reference to the need for good lighting was wanted, but that, at the present moment, the time was not quite ripe to frame a precise standard of illumination. This is in accordance with the views expressed in the journal that it is essential to move cautiously and moderately in this matter. On the other hand, the evidence of some of the inspectors suggests that the comparative simplicity of modern photometric measurements is not quite fully appreciated, and that progress in the direction of judging the amount of light required has gone a little further than those not closely connected with illuminating engineering might be disposed to think. No doubt, now that these matters are receiving attention from the authorities, the actual progress in this direction will be closely studied.

How Bad Illumination Leads to Accidents.

A great deal of the evidence also serves to show how readily fatalities occur in badly lighted premises. For example, Miss Lewis, a member of the Oldham Committee of the Amalgamated Weavers-Winders' and Warpers' Association, in referring to the Lancashire mills, remarked "There are many dark passages leading from one room to another. When going from the light into the dark you cannot see the state of the floor. Most of the people in the Lancashire mills wear clogs, and that causes them to slip if the floor is in a bad state." Other witnesses also lay stress on the danger of poorly lighted passages. Mr. J. Smethurst, a representative of the Federation of Master Cotton Spinner's Association, and thus speaking from the employers point of view, agreed that badly lighted passages and staircases were so obviously prejudicial that the matter ought to be put right without the inspectors calling attention to it.

As further illustration we may also quote some comments of Mr. H. J. Wilson, H.M. Inspector of Factories, Glasgow, on such accidents :—"These all seem preventable accidents if the places were decently lighted, but they are insufficiently lit. I have known cases of men killed with locomotives when it was doubtful if the light was adequate. Want of space is another cause of accidents. I have known fatalities with locomotives to occur owing to want of space, but this is not a very common cause of accidents in ordinary factories. There are certain exceptions. In brick making sometimes men have to work in dangerous proximity to the machine and the danger is aggravated by poor artificial lighting. In rope spinning I have known cases where the machines were so close together as to make the risk much more serious."

The question of overcrowding is frequently referred to, and is often indirectly the cause of accidents. Thus Mr. G. Sedgewick remarks that "the machinery in some cases impedes the light, and want of light is one of the causes leading to accidents. Give men plenty of light in a room, and the chances are that even with machinery which has dangerous parts they will be comparatively free from accidents."

Illumination in Ship-Building Yards.

In the same way Mr. Johns, Technical Adviser for the North-East Coast of the Ship Constructive and Shipwright's Association, gave a number of instances of accidents occurring owing to workmen not being able to see their way in dark passages, and being even obliged to work overtime in total darkness. For example, he remarks, "I have one case in my mind now. A man, on coming on board ship in the morning and going to his work, whether he forgot the condition the place was in when he left it the night before, walked quite unconsciously into a dark place where there was a hole, and dropped through the hole. That hole should have been covered up, but,

at the same time, the man should have exercised a certain amount of care himself. I never went aboard a ship unless I had a box of matches on me, but everybody is not so careful." Another point is that bright lights of high intrinsic brilliancy, such as naked arclamps high up, may sometimes throw such sharp shadows as to produce accidents through this cause. For example, a case is mentioned of a man who fell; even those looking on thought the man was stepping on a plank at the moment when he walked over an open space and was killed.

A similar view was taken by yet another Inspector, Mr. W. F. Ireland, who added that efficient lighting was especially desirable in all places where there is dangerous machinery. It was not only the amount of light, but also the way in which the lamps were arranged that was important. He added, "I have experienced myself, on going into factories when night-visiting, particularly where there were arc-lights, that they seemed to cast a very confusing shadow, and that sometimes what you thought was a shadow on the floor was really a casting, and you tripped over it. I have done that myself in visiting factories."

In the same way Mr. J. Hill pointed out the danger of carrying out work in shipbuilding yards of the vessels before daylight. He remarks: "While lighting in most shipbuilding yards is better now than it used to be, it will never be possible to eliminate the danger from darkness in ship building. Working in the dark in the winter time is the cause of very many accidents; there are far more accidents in the early morning than there are at any other time. To go about in the morning, when there is a strong wind or a frost is exceedingly dangerous in a shipbuilding yard. I think it should be universal not to begin work before daylight. A good many employers in certain districts do not begin before daylight, but all over Scotland they begin at the same hour in the winter as in summer."

Defective Naphtha Lamps.

Another fault mentioned is the using of naphtha lamps of defective construction. Some such lamps are not only productive of an atmosphere in which it is difficult to breath, but are also dangerous, because the slightest leak is apt to lead to the whole lamp bursting into flame. "Explosions," Mr. Hill added, "only occur through carelessness or occasional bad lamps, but the danger to health is always present." He thinks that in the confined badly ventilated places often found on board ships it would be safer and more hygienic to use electricity. When asked whether he was aware of recent instances of accidents having happened because of insufficient light, or because of the bad burning of such naphtha lamps, he said, "Such accidents are occurring every day in the ship-building districts."

There seems to be a need, therefore, for closer attention to be paid by employers to the kind of portable lamps that can be used with safety. Now that so many modern improved forms of lamps are available, it should be possible to reduce this danger to much smaller proportions.

Good Illumination essential in Iron Foundries.

Mr. J. W. Frost, a member of the Friendly Society of Iron Founders, gave some striking evidence on the subject of the need for good lighting in foundries. He remarked that there has been of late years an increase in the number of accidents. When asked if he could give an explanation of this increase he replied, "Yes. We contend, in fact we are certain, that iron foundries are the worst lighted departments in the whole of the engineering section; in fact, I have been in foundries where you can scarcely see to walk about, let alone work." A frequent cause of accidents is that men come along carrying ladles of molten metal, which spill on to the plates on the floor, and form small nodules. The next man comes along, and is very apt to slip on these if the illumination is poor, so that he cannot pick his way carefully. Needless to say, such a slip would often be a serious matter for a man carrying a ladle of molten metal.

In the course of further evidence Mr. Frost insisted upon the need for frequent lime-washing in foundries on account of the amount of dirt and dust that is present. In summing up the cause of the complaint on the subject of lighting he added, "Our complaint is that we have not sufficient, as I said at first. We can go into foundries where we can scarcely see, and where they have to carry metal; you will have an idea what it must be like in dark weather. When a place is so dark and a man's eyes have been looking for some time at molten metal, he cannot see very far before him under those conditions."

Data Needed on Accidents and their Causes.

It is interesting to note that these witnesses recognize the difficult position of inspectors in the absence of precise instructions as regards lighting. Another matter that evidently requires attention is the examining of records with a view of ascertaining what proportion of accidents occur through insufficient lighting. Mr. Frost expressed his strong conviction on this matter, but he pointed out that there were not available adequate records to support this contention. In conclusion, he repeated his contention that more light was needed: "We do not care whether it is gas or electricity," he said, "so long as we can get more of it!"

This same point—the need for collecting data on the effect of bad lighting on mishaps—was admitted by Mr. J. H. Rogers, who pointed out that it was difficult to recognize which accidents occur through poor illumination. He remarked "We cannot tell how many occur indirectly, because we certainly have some badly lighted places, and it is difficult to attribute a machinery accident to bad lighting. The sort of accident which is most frequent is that arising through stumbling in dark passages."

One other question which seems to be worthy of notice is that of the time in the evening at which artificial lighting becomes necessary. There is sometimes a tendency to go on working by fading daylight too long before it is realized that more light is needed. Thus Mr. J. H. Crabtree remarks that "winter mills are not lighted early enough....There are accidents through carrying hot water jugs, &c., in such cases. It is common enough to find lighting done within five minutes of my entry. Inadequate space is a common fault in mills." He also added that strain on the eyes was a natural cause of bad lighting, and would make the work more liable to accidents.

From the series of quotations that have been made it is evident that the question of good illumination is now receiving very close attention, and that there is a recognition on the part of both inspectors, employers, and employees that some improvement is necessary. The evidence seems to have been of a thorough practical character many obvious dangers arising through poor lighting being pointed out. The chief need now seems to be for fuller data regarding the variety of illumination required in different workshops and factories and the precise ways in which bad illumination leads to accidents and produces unhygienic conditions. We may be sure that the data will now be forthcoming, and that we shall soon be in a position to state the requirements of various factories more precisely.

[This Blue Book (Cd. 5540) has just been issued and can be obtained through any bookseller.—Ed.]

Prize Offered for Miners' Safety Lamp.

We notice in the daily press an announcement that a colliery proprietor has placed at the disposal of the Home Secretary £1,000 to be offered as a prize for the best type of electric safety lamp for miners.

The Illumination of an Up-to-Date Bakery.

(An account of the Inverted Arc Lighting Installation at the New Machine Bakery of the Reading Industrial Co-Operative Society, Ltd.)

BY AN ENGINEERING CORRESPONDENT.

THE illumination of a modern bakery, like other problems in illuminating engineering, must be specially planned out according to the requirements of the trade. One finds that in every business there are certain circumstances which the lighting engineer must bear in mind; he must, in fact, besides having a knowledge of the technicalities of lighting, study, to some extent, the particular kind of business for which the illumination is intended. It is just this extra piece of attention that makes the difference between highly successful and only moderately good lighting.

Illumination is a matter of no small importance in a bakery. The conditions of the trade are such that a very large proportion of the actual baking is usually done during the night time by artificial light, the routine business of disposing of the bread, &c., being attended to during the day.

Perhaps for the above reason, baking is not infrequently carried on in underground premises where artificial lighting must be relied upon almost exclusively. Naturally, therefore, the cost of the lighting bill is of more consequence than in businesses in which artificial light is comparatively seldom used. But apart from the question of economy, the importance of the artificial illumination being thoroughly satisfactory under such circumstances can hardly fail to be recognized. In trades in which artificial light is only used now and then defects, although irritating, may not have a very serious influence on the business. But when one is practically dependent on artificial illumination, the whole success of operations is bound up with the conditions being up to the mark. The time taken for the simplest operation is a direct function of the illumination provided; and if the lighting is faulty, if one cannot see to carry out work in comfort, the percentage of spoilt work is inevitably increased.

One other important matter is the influence of good illumination in promoting cleanliness. With a dim and feeble light the risk of utensils not being kept scrupulously clean, and the tendency towards disorder and the accumulation of dust are much increased. Nothing is more effectual than good lighting in inspiring confidence that work is carried out in a reliable manner, and under clean and whole-

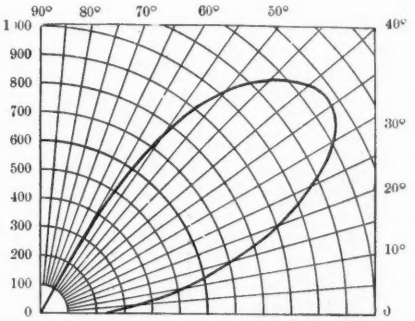


FIG. 1.—Showing distribution of light from Union Electric Co. OI inverted arc lamp, size E, 10 amps., 42 volts, mean hem. c.-p. 770.

some conditions; if one finds that baking is done in ill-lit, disorderly premises, one is at once apt to doubt the satisfactory nature of the work. In this case the perfect order in which everything is kept, and the tidiness of the various rooms, are in no small measure due to the excellent illumination.

A glance at the recent reports of H.M. Inspector of Factories shows that an increasing stress is being laid on the need for good illumination in basement interiors. Hygienic authorities are naturally concerned to see that the sanitary conditions as regards lighting,

ventilation, &c., are specially well cared for in such cases, and the provision of abundant and well schemed out illumination will go a long way towards creating a feeling of satisfaction in this respect.

Nature of Good Illumination.

The chief requirements in a lighting installation of this kind may be very simply stated. There must be sufficiency of illumination. The light must be distributed so that every corner receives its full share of light, and there are no regions of dark shadow and obscurity; the actual source of light should be so arranged that the eye is not troubled by "glare." Then there is one other matter of some consequence—the colour of the light. In this case the actual baking is carried out by artificial light, but the products are disposed of in the daytime. It is therefore to be desired that the colours of things should appear very similar under both kinds of light; otherwise it is uncertain what the fancy cakes, or confectionery with coloured icing, &c., will appear like in the daytime. (In badly-lighted premises one even sees material being carried out of the baking room at intervals to some spot where daylight is available so as to make sure on this point!)

All these requirements have been carefully studied in the "Eye-comfort" system of inverted arclighting used in the Co-operative Society's Bakery, and the way in which these requirements are met will be described in the course of the article.

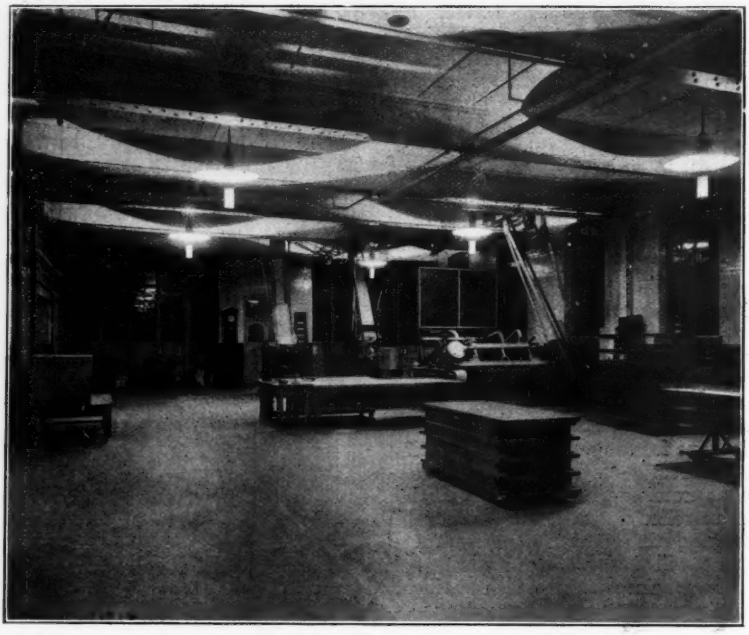


Fig. 2.—Room containing automatic bread-making plant, mean illumination 3·95 foot-candles. Diversity co-efficient (max./min.) 1·3 watts per sq. foot 0·98.

Lighting Arrangements.

The Reading Co-operative Society's Bakery generate their own current by means of a dynamo-generator driven by a gas engine run from the town's gas, at an inclusive overall cost of 1*d.* per unit. The rooms are lighted indirectly by arclamps of the Union

Electric Co.'s OI type, which are run two in series on 110 volts. Each lamp takes 10 amperes and consumes 550 watts, thus representing a cost for current per lamp per hour of 0·55*d*. The carbons (upon the basis of an annual contract) cost 18*s*. per 100 pairs, or 2·16*d*. per single pair. Each pair of carbons will burn for 14 hours, so that the cost of carbons per lamp per hour is 0·155*d*. The total cost of both current and carbons per lamp per hour is therefore equal to 0·55*d*. + 0·155*d*.=0·705*d*.

The mean hemispherical candle-power of each lamp is 770. The specific consumption in watts per M.H.C.P. is 0·71 and the total cost current and carbons per 1,000 (mean hemispherical) candle-power-hours is thus 0·915*d*.

The nature of distribution of light as shown in Fig. 1 is also of interest. The light is thrown up on the ceiling, and the polar curve of light distribution of these arclamps is specially designed to secure conditions of uniform illumination with the lamp at an appropriate distance from the ceiling. The result is a wonderfully well distributed illumination, the light penetrating to all corners of the room and enabling every detail to be clearly seen; a good feature is the complete screening of the lamps from the eyes with a view to eliminating glare.

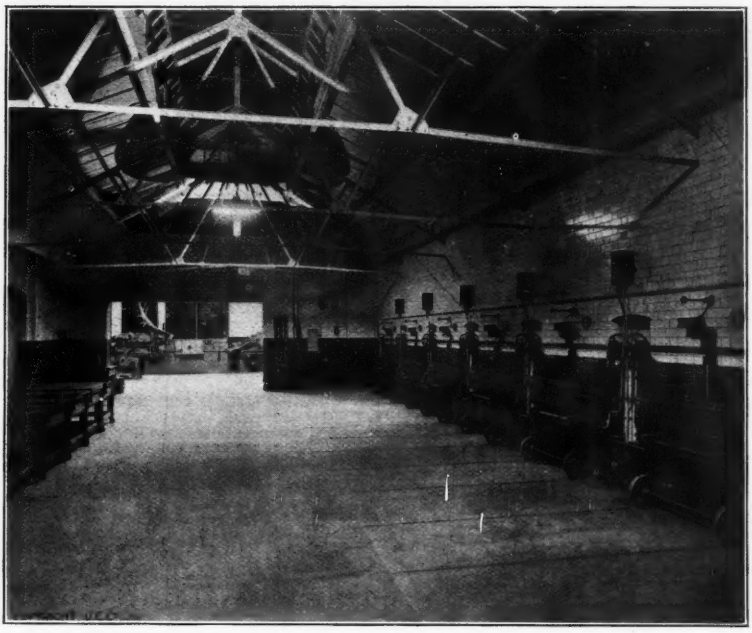


FIG. 3.—Room containing gas-fired ovens. Mean illumination 2·43 foot candles. Diversity co-efficient (max./min.) 2·5 watts per sq. foot 0·52.

CONDITIONS OF ILLUMINATION OBTAINED.

The general nature of the illumination will be readily appreciated from the photographs shown in Figs. 2, 3, and 4. In these rooms the floor is of concrete and the walls of brown and white glazed bricks, which represent the actual appearance of the rooms when lighted up for work. Fig. 2 represents a room devoted to the automatic bread-making plant. Six

lamps, in two rows of three, are installed.

The average floor illumination is just under 4 foot-candles. The maximum is 4·3 foot-candles, the minimum 3·1 foot-candles, and the "diversity-coefficient" (the ratio of max. to min. illumination) is therefore only 1·3. This figure is generally regarded by engineers as the criterion of the evenness of illumination secured, and the above result would be difficult to surpass by any system of illumination.

This shows, therefore, the excellent distribution of light for general purposes. Special attention, however, was paid to the central table, the surface of which is 3 feet above the floor level. This is used for placing the dough upon preparatory to baking, and a strong and even illumination is here particularly essential. Experiments showed that the average illumination on the tables was 5·26 foot-candles, the maximum 5·6, and the minimum 5·1, so that the diversity-coefficient is here 1·09. In the same way the average illumination on the working plane and the controlling levers of the automatic bread-making plant (seen on the right-hand side of the photograph) was 5·76 foot-candles, and the diversity-coefficient the same as above.

When it is recalled that the illumination considered sufficient for reading even fine print is considered to be about 3 foot-candles, it will be seen that a very generous margin is here provided.

FIG. 4.—Room containing dough-kneading machines. Mean illumination 3·92 foot-candles. Diversity co-efficient (max./min.) 1·2 watts per sq. foot 0·9.

It may be added that the dimensions of this room are 84 feet long by 40 feet broad by 16 feet high, and the watts per square foot of floor area are only 0·98—an exceedingly low figure in view of the high illumination provided.

The second photograph (Fig. 3) shows the room containing 6 gas-fired ovens. Only two lamps are here used, and the average illumination is 2·43 foot-candles; the diversity-coefficient is

2·5. This, although not high, is not quite so satisfactory as in the former case. The explanation is that the lamps were spaced rather too far apart, with the result that the illumination falls to 1·4 foot-candles in a small region in the centre of the room. A substantial improvement in this respect could probably be made by bringing the lamps closer together. The watts per square foot in this room correspond with the lower value of the illumination considered necessary, being only 0·52.

Fig. 4 shows the mixing room. The dough kneading machines are on the left-hand, the storage bins on the right-hand side of the photograph. Four lamps are installed in this room. The average illumination on the floor level s 3·92 foot-candles, the maximum 4·2, and the minimum 3·5; the diversity-coefficient is thus 1·2.

The watts per square foot of floor surface amount to 0·9. This room was an exceptionally low one, the height of the over-reflectors from the floor being only 9½ feet. The uniformity and efficiency of the lighting under these circumstances is surprisingly good.

Measurement of Illumination, Photographs by Artificial Light, &c.

The measurements of illumination were made with the Holophane Lumeter instrument, and the use of the separate screen was found very serviceable, both in enabling the general illumination to be studied, and in determining the illumination on certain tools and apparatus. The apparatus was also utilized as a means of judging the exposure given in taking these photographs, which was deduced from observations of the surface-brightness in the rooms in a manner recently described in a paper before the Royal Photographic Society.*

These two sets of data, *i.e.*, the presentation of actual measurements of illumination, and also of photographs showing the appearance of the rooms when illuminated by artificial light, go hand in hand as in enabling the excellence of the conditions of illumination to be judged. The photographs, it should be explained, were *taken solely by the artificial light* provided. They were not retouched in any way, and they therefore present an accurate picture of the rooms just as they appear in practice.

In conclusion, it only remains to be added that the installation has given great satisfaction. The output of the bakery is of a large and very varied nature; 60,000 loaves a week are turned out on the average, exclusive of confectionery, fancy pastry, wedding cakes, &c. It is significant that the trade of the bakery is showing a substantial increase week by week. The

Fig. 5.—Union Inverted Arc Lamp, Pattern OI, Size E, with Over-Reflector.

improved conditions under which the work is now carried on are very much appreciated by the workers, many of whom have had experience of the unsatisfactory dim light in which such work is still sometimes done. The installation was admirably executed by Messrs. Baughan & Co. of Reading, the local agents of the Union Electric Co., in conjunction with the Co-operative Co.'s electrical staff. Acknowledgment should be made of the courtesy of the Union Electric Co., Ltd., in affording information and such excellent illustrations of the installation, and also that of the Co-operative Company in granting permission for the necessary photographs and measurements to be made.

* Surface Brightness, its Measurement and its Application to Photography, by J. S. Dow and V. H. Mackinney, *Photographic Journal* (London), April, 1911.

Standard Specifications for Street Lighting.

SOME ANSWERS TO QUERIES CIRCULATED PREVIOUS TO THE MEETING OF THE JOINT COMMITTEE ON THE SUBJECT IN THIS COUNTRY.

IN the May number of *The Illuminating Engineer* (pp. 301–309) we published an article dealing with the various suggestions that have been put forward during the last few years regarding standard specifications for street lighting.

Consideration of this article shows that there are certain points on which a distinct division of opinion seems to exist, and the list of queries to be found on the following page was therefore prepared and circulated. As is well known, the matter is exciting much attention in this country, and it therefore occurred to us that it would be of value to learn the views of authorities in the United States and on the Continent interested in this subject. Replies from some of the gentlemen approached are still awaited, but the views of the following authorities have already been received :—

DR. LOUIS BELL, Consulting Electrical Engineer of the Edison Electric Illuminating Co., Ltd., Past President of the Illuminating Engineering Society (BOSTON), U.S.A.

DR. L. BLOCH, Lighting Engineer to the Berlin Electricity Supply Co., Member of the Photometrical Committee of the Verband Deutscher Elektrotechniker (BERLIN).

PROF. DR. H. BUNTE, Professor at the Technische Hochschule, KARLSRUHE, Gen. Secretary of the Verein von Gas u. Wasserfachmännern, Editor of the *Journal für Gasbeleuchtung u. Wasserversorgung.*

PROF. H. DREHSCHMIDT, Chief Chemist of the Municipal Gas Works, Tegel (BERLIN).

HERR J. HERZOG, Elec. Engineer (BUDAPEST).

DR. H. KRÜSS, Chairman of the Photometrical Committee of the Verein von Gas- und Wasserfachmännern (HAMBURG).

MR. P. S. MILLAR, Elec. Testing Laboratories (NEW YORK), Gen. Secretary of the Illuminating Engineering Society (U.S.A.).

DR. B. MONASCH, Chief Engineer to the Wolfram Lamp Co. (AUGSBURG), Member of the Photometrical Committee of the Verband Deutscher Elektrotechniker.

PROF. S. A. RUMI, Professor of Technical and General Physics at the R. Instituto tecnico e nautico (GENOA).

HERR K. SATORI, Electricity Supply Works (VIENNA).

HERR M. SCHOLZ, Director of Messrs. Ehrich & Grätz (BERLIN).

PROF. H. STRACHE, Professor at the K. K. Technische Hochschule (VIENNA).

PROF. J. TEICHMÜLLER, Consulting Electrical Engineer and Professor of Electrical Engineering, Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker (KARLSRUHE).

DR. W. VOEGE, Assistant in the Physikalische Staatslaboratorium (HAMBURG), and Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker.

It is hoped that this summary will be made more complete as soon as replies are received from a number of other authorities, but meantime this collection of the views of Continental and American experts should be found very valuable. Special acknowledgment should be made of the courtesy of these gentlemen (who, it may be remarked, are all Corresponding Members of the Illuminating Engineering Society) in so readily placing this information at our disposal.

The following is the list of queries presented :—

RE FRAMING STANDARD SPECIFICATION FOR STREET LIGHTING.

1. Ought the specification to contain a statement of : (*a*) The electrical energy or gas to be consumed ; or (*b*) the amount of light provided ; or (*c*) both energy or gas consumed and amount of light ?

2. Should the amount of light supplied be specified in terms of (*a*) The provision of a certain actual minimum illumination in the street ; or (*b*) the provision of lamps of a certified candle-power ?

3. If illumination is to be measured, should this measurement be carried out (*a*) in a horizontal plane at a stated height above the ground ; or (*b*) in a vertical plane ; or (*c*) in some other inclined plane such as 45 degrees ? (*d*) Should both the mean and the minimum street illumination be measured and specified ?

4. If candle-power is to be tested in the street should (*a*) the mean spherical or mean hemispherical c.-p., or (*b*) the c.-p. in several specified directions be tested ?

5. Should the contract demand (*a*) actual measurements in the streets or (*b*) only laboratory tests of the competing lamps previous to the acceptance of a tender, or (*c*) preliminary laboratory tests supplemented by periodical tests of the actual lighting conditions when the lamp is in position ?

6. Should any test of the constancy of the candle-power of the lamps be prescribed ?

7. Do you advocate the introduction of any stipulation regarding the efficient shading of lamps, height above ground, &c., with a view to the avoidance of glare, such as is recognized to be dangerous and inconvenient to traffic and pedestrians ?

8. Should any specific colour of the light be prescribed ? If so, how should this be tested ?

9. What other clauses would you suggest being inserted ?

In what follows we print verbatim the information received, and at the conclusion of the article a table is presented in which the opinions of the various experts are summarized, thus enabling us to see at a glance on which points agreement seems possible, and in what respects considerable divergency in opinion still appears to exist.

Answers to questions regarding Proposed Street Lighting Specifications.

Dr. Louis Bell (*Boston*, U.S.A.).—1. The electrical energy or gas to be consumed should be directly stated in the specification, since this is a quantity which is susceptible of relatively accurate measurement, and the output of the light is sometimes very sensitive to small changes in the energy or gas furnished. Furthermore, it is not sufficient, generally speaking, merely to state these quantities. My own form of specification for arc lamps, for example, requires that the current delivered to the lamp shall not fall below a specified number of amperes, nor the energy at the arc, or at the lamp terminals, below a specified number of watts. With incandescent lamps of a definite kind watt measurement alone is sufficient, but in the case of gas both the quantity and pressure should be specified.

2. I do not believe in the specification of illumination in any form as the basis of payment in a municipal contract. Some attempts have been made in this country to sell illumination as such, on the somewhat specious basis that it is the thing really desired. I am not quite willing to go so far as to say that any such contract is made with intent to deceive, but experience has taught me that contracts put in this form are generally for the purpose of utilizing illuminants that would have no standing on the basis of spherical candle-power, and with the intent of furnishing not as much illumination as possible for the funds available, but as little as will meet the minimum specification. Moreover, the measurement of illumination in the streets, particularly when in amount near the low minima, too common in American practice, is at best a somewhat rough approximation, very difficult to bring within the limits of accuracy that would be tolerable as a basis for payments. When a municipality is spending, say, twenty thousand pounds a year for street lights, an error of 5 or 10 per cent in-

volves a sum altogether too great for such casual treatment, and it is quite certain that measurements made under the direction of the two parties to the contract might easily differ by such an amount. On the other hand, the provision of lights of a specific minimum candle-power insures that at least a certain minimum flux of light will be available for illuminating purposes, and it is then the business of the engineers of the municipality to utilize this flux to the best advantage.

3. I do not believe, as I have just stated, that illumination as such should be measured at all as part of any contractual arrangements. The engineers in behalf of the municipality may find it useful for their own purposes to make such measurements. Personally, I generally measure the illumination on a plane normal to the ray from the lamp. For this reason, that the severest demand in street illumination is ability to read an address book or time-table, which is customarily held in this position to get the best available light. Of course this means taking the illumination between lamps from only one direction, which again is a condition fulfilled in such a reading test. With our American habit of spacing lamps on the whole rather too widely I find this the best practical plan. Were I dealing with the closer spacing and higher minimum illumination found in some British and Continental cities I think I should prefer the measurement on a horizontal plane at some convenient distance, say a meter, above the ground. With the spacing and height of suspension quite common with you in Great Britain and on the Continent the value found in this way will commonly be not far distant from that which I reach by the previous method. If any illumination at all is specified or measured, both the mean and the minimum should be included. Otherwise the contractor is likely to keep to the minimum value just as far as is possible and the street will not generally be well lighted.

4. If candle-power is tested at all in the streets, as I think it should be from time to time to see that the performance of the lamps is meeting the standard set, it should, I think, be measured in a single specified direction, the relation of which to the total flux of the lamp can be pretty definitely settled by laboratory tests. Here in Boston our routine tests of the lamps are made at an angle of 25 degrees below the horizontal.

5. The contract should demand such photometric tests of the competing lamps as shall settle their average performance in light flux and nature of distribution. Thereafter it is desirable to make occasional tests to see that the lamps are being kept up to their contract condition. If a specified type of lamp thus investigated is operated under specified conditions of energy supply, and followed up by occasional street tests, one is pretty certain to insure good lighting. In drawing a specification I usually provide that a lamp which falls below a certain specified limit shall be considered as out for a stated period, and the proper penalty is applied.

6. The process indicated under 5 will generally be efficient in meeting reasonably constant candle-power. Of course a lamp which is conspicuously bad in the matter of flickering would not be accepted as a standard type under any reasonable contract.

7. I am accustomed to specify the limit of heights within which the lamps shall be placed, varying, of course, according to the type of lamp, and the use of diffusing globes, wherever the circumstances of use make such desirable to avoid glare. I always advise them for the more powerful illuminants, such as arc lamps and high pressure gas lamps, and occasionally where circumstances require for ordinary incandescents, both gas and electric.

8. I do not think that a specific colour of the light should be prescribed. That question can be settled in selecting the type of lamp to be used under the contract. I can hardly imagine a test of colour being specified unless with the purpose of shutting out some particular illuminant, and this is better done by frankly disqualifying it.

9. I think that the thing really furnished and paid for in any municipal lighting contract should be not candle-

power, illumination, or energy, but service with certain specified lamps operated under specified conditions of energy supply. The light flux from these lamps can be determined in the laboratory, and the lamps themselves so placed as to give such illumination as in the judgment of the municipal authorities is desirable. These authorities should in general have the right to specify the location, spacing, height of lamps, and to hold the undertakers up to the mark in these respects. In case of using diffusing globes I have sometimes found it desirable to have certain samples placed in the custody of the municipality to which any globes in use must conform. In one recent instance I applied the same principle to the electrodes used in arc lamps. A certain number of samples approved by the engineer after tests were held in custody and the subsequent supply of electrodes being purchased by the lighting company in quantity were sampled on the photometer as against the standard. The main thing, I think, in any such contract, is to set a high standard of service with an illuminant of which the properties can be definitely determined and then to direct periodical tests to insure that the service is properly kept up.

I think these comments will make my views on the contract question clear. It must be remembered that they are the result of experience under American conditions, and I do not think myself competent to judge whether they will equally well meet British conditions. The bane of American practice has been too wide spacing of lights, and consequently too much attention to the minimum conditions. Further, we generally do not classify our streets judiciously, so that streets which require good lighting are too often sacrificed in the interest of uniformity to those in which a very modest amount of light would suffice.

Dr. L. Bloch (*Berlin*) :—

The efforts being made to establish a standard specification for street lighting are exceedingly interesting to me, and I gladly comply with the request to give my views on this matter. I have already published an account of the recommendations of the Verband Deutscher Elektrotechniker.* This was submitted for the approval of the Verein von Gas- und Wasserfachmännern, but no official pronouncement on this point seems to have yet been made.

As regards the queries in your circular, it may be asked whether what is proposed is of the same nature as our recommendations for judging illumination, referred to above, or what is generally known as a specification? I judge that the latter is what is aimed at, and in this case the first question that arises is whether the tendering parties shall merely supply certain lamps, as hitherto, or provide specified conditions of illumination. Should the first course be followed, chief importance would be attached to the candle-power furnished by the lamps, but in the latter case we should be concerned mainly with the actual illumination secured. But in any event the amount of energy consumed by the lamps should also be specified.

With us, as with you in England, the difficulty is encountered that the candle-power of various lamps is taken in different directions (*e.g.*, horizontal, hemispherical, spherical, &c.). In any case the intensity of a light cannot be determined correctly by measurements at various angles in the streets, and according to my view it is better to dispense with this method and rely upon taking measurements of the actual illumination in the street.

As regards the plane of measurement, height of observation, &c., I naturally abide by the German recommendations, inasmuch as these are the result of my suggestions. Especially would I urge that the measurement of the maximum value of the horizontal illumination should not be disregarded, as this is necessary in determining the degree of uniformity, and, in the case of very weakly illuminated streets, possesses the greatest significance.

In glancing over the list of queries it strikes me that the proposal contained in No. 5 is most correct, if lamps are tested for candle-power in

* *Illum. Eng.*, Lond, vol. iii. 1910, p. 403.

the laboratory, but the actual illumination measured in the street.

The point raised in No. 6 regarding the constancy of light from street lamps bears mainly on the fluctuations of short duration on the part of many arc lamps. I consider that the time is not ripe for regulations on this matter, in view of the fact that no reliable means of measuring such variations can yet be said to exist. In the same way precise recommendations can hardly as yet be made on such questions as the use of shades and reflectors, the desirable height of lamps, avoidance of glare, &c. These prescriptions are better left to a later period when more perfect unanimity shall have been secured on these highly controversial matters.

Prof. Dr. W. H. Bunte (*Karlsruhe*) and **Prof. Dr. H. Drehschmidt** (*Berlin*) in collaboration :—

1. It does not suffice to specify either candle-power or consumption of gas and electricity alone ; both quantities should be stated, as the efficiency of different varieties of lamps varies within wide limits.

2. It is recommended that a certain minimum illumination in the streets should be specified, and not the candle-power of the lamps, since the latter would not indicate sufficiently the effect on the resultant illumination in the street of differences in the polar curves of light distribution.

3. For the routine supervision of street lighting, measurement of illumination on a horizontal surface about the height of the head is sufficient ; for when certain sources having a known polar curve of light distribution are being used the vertical illumination can be deduced from the horizontal. Yet in comparing the merits of the different methods of illumination the brightness of the illumination in a vertical plane should be considered, as this is very essential in enabling the faces of people and surrounding objects to be clearly seen. In deciding upon the adoption of a certain system of illumination the relation between the horizontal and vertical illumination should therefore be borne in mind. Measurements in a plane inclined at 45° present no advantages over vertical and horizontal determinations.

4. A determination of mean spherical or mean hemispherical candle-power is surely not practicable (in the streets). Instead measurements of illumination at specified distances from the foot of the lamp post are desirable.

5. Preliminary measurement of candle power in the laboratory is to be recommended, but not mean lower hemispherical c.-p. alone. Tests of candle-power in various directions are desirable, and the polar curve of light-distribution should be ascertained. The lamps should subsequently be tested in the open to ascertain whether any defects in practical working will reveal themselves (*e.g.*, as regards maintenance, protection against wind, steadiness of light, &c.). When these tests have been passed satisfactorily the installation of the lamps in the streets may be proceeded with, and their performances tested by periodical measurements on the spot.

6. It is difficult in the light of present experience to prescribe numerical limits to the steadiness demanded from lamps ; perfect constancy is not attained in the electric arc lamp, by reason of the etching of the glass and the deposit of fumes on the globe nor, in the case of the incandescent gas lamp, on account of the deterioration of mantles respectively. Possibly one might put forward the tentative suggestion that the limit of diminution should be not more than about 65 to 70 per cent of the original candle-power.

7. The height of the lamp cannot be rigidly specified, since this is naturally dependent upon the kind of lamp used ; a source whose light is developed over a small area, and which has a high intrinsic brilliancy, must be hung at a greater height than one for which the intrinsic brilliancy is low.

8. A certain colour of light cannot be readily specified. One can only abstain from using lamps which give a very peculiar and undesirably tinted light.

9. No special proposals to be added.

Herr J. Herzog (*Budapest*), in addition to information regarding the conditions of gas and electrical supply in Budapest, refers with approval to an exhaustive test recently carried out in that city by a joint committee of experts. These were described in *The Electrical World* by F. Jehl (vol. liv., 1909, p. 986). These researches were also mentioned in the previous article on the subject of the standard specifications in the May number of *The Illuminating Engineer*. It will be recalled that measurements were made in a horizontal plane, a specially treated magnesia screen being used for the purpose, and data regarding maximum, minimum, and mean illumination collected.

P. S. Millar (*New York*) :—

1. (*a*) Yes ; (*b*) No ; (*c*) No. I favour specification of a *stated type of lamp*, consuming stated watts or cubic feet of gas.

2. (*a*) No ; (*b*) No. The minimum illumination, while important, is inadequate as a measure of illuminating effectiveness. As to certified candle-power see (1).

3. I believe that illumination tests on any single plane fail to tell the whole story. The horizontal plane on the surface of the street is most important ; with vertical illumination 5 feet above the street surface, not to be neglected.

4. Considerations of practicability limit candle-power tests in the streets to measurements in certain directions. The form of distribution curve for a given type of illuminant may best be determined in a laboratory—its numerical value should be determined by reference to street tests of candle-power in stated directions.

5. See answer to 4.

6. Desirable, if practicable.

7. No. This may come later, but our best efforts to-day may be directed along lines of investigation of this problem and public education in these matters.

8. No.

9. If in any request photometric tests are involved in a contract, a competent independent third party should be named to conduct the tests, and a reasonable non-penalty margin should be provided to allow for inherent variables and fallibility of tests. Particularly in the proposed tentative specifications should the interests of all parties to the contract (including the contractor) be cared for. Rigid new provisions, apparently assuring every interest of the public, should be tried for a reasonable period before being incorporated in specifications.

Dr. B. Monasch (*Augsburg*) and **Dr. W. Voege** (*Hamburg*) express their approval of the recommendations of the Verband Deutscher Elektrotechniker ; their comments on the list of queries are in tabular form, and are embodied in the summary at the end of this article.

In connexion with Query 3 Dr. Monasch adds :—

I believe that those concerned with gas lighting were inclined to prefer measurements of illumination in a vertical plane (whereas electrical engineers habitually make measurements horizontally), so long as only upright mantles were in use. But since inverted gas mantles, which give a very powerful light in the lower hemisphere, have been so largely adopted, the distinction between the distribution of light from the two illuminants has been less marked. In consequence of this, representatives of gas lighting seem disposed to reconsider their former position, and to view horizontal measurement in a more favourable light. Personally, I regard the vertical illumination as no satisfactory criterion, since the calculation and graphical determination of such values is so inconvenient.

Prof. S. A. Rumi (*Genoa*) :—

The terms of a contract in Italy are usually based on a predetermined plan in which the kind of lamps used, their candle-power, and their arrangement are definitely stated. This method is followed because the conditions of lighting required in different places are very similar. It is, however, customary for the illumination to be most intense in the most frequented streets and squares, and higher in town thoroughfares than in the case of roads of a more rural character. In a contract of this kind it seems desirable to state every item as precisely as possible,

and it should contain statements regarding :—

1. (*a*) The amount of light (mean hemispherical c.-p.).

(*b*) The quantity of gas consumed by each burner in the case of an incandescent gas lamp, or the electric energy consumed and pressure required across the terminals of an electric lamp.

2. The provision of lamps of specified candle-power.

3. The actual out-door illumination depends not only on the candle-power of the lamps used, but also on such circumstances as the mistiness of the atmosphere ; it is therefore not desirable to make the illumination the subject of rigid specification.

4. Mean hemispherical candle-power should be measured, and some form of limit should be set to the nature of the polar curve of light distribution.

5 and 6. Note remarks in No. 3. Satisfactory comparative tests can only be made in the laboratory. But if limits are prescribed within which the light must not vary periodic observations are necessary.

7. The light adopted should possess a continuous spectrum, and should be as nearly as possible white in colour.

Herr K. Satori (*Vienna*) :—

1 and 2. I consider that it is desirable to state the actual illumination in lux given to the street rather than the absolute quantity of light from the lamps installed ; special stress should also be laid on the illumination being as uniform as possible. This is naturally much easier to secure by specifying certain limits to the actual illumination in the street. As regards point *c*, it may be noted that although one naturally aims at as high an efficiency as possible, there are yet certain selectively radiating sources, such as the mercury vapour lamp, which give light of a peculiar colour, and which would hardly be used for street lighting.

3. It suffices if illumination is measured in a horizontal plane.

4. As stated above, the specifying of the candle-power of street illuminants, as well as the direction in which this candle-power should be measured, seems to me somewhat objectless, for what is desired, is not the candle-power of the lamps, but the provision of a certain specified ground illumination.

7. In lighting the outsides of shop premises, for illuminated signs, &c., high-power lamps are often used at a low height. In such cases the lamps are apt to constitute an interference to passers-by and to traffic, and they should be screened on the side facing the street.

8. Referred to above.

Added.—I consider the recommendations of the Verband Deutscher Elektrotechniker* very serviceable. The only difficulty is to state exact limiting figures for the illumination, since this is, to some extent, a matter of opinion.

Herr Max. Scholz (Messrs. Ehrich & Grätz, *Berlin*).

1. In my opinion a specification ought to contain a statement of both energy or gas consumed *and* the amount of light produced, the proportion of the two to be the base upon which the values of competitive illuminants may be compared.

2. It is very difficult indeed to give a definite answer to this point. When gas lamps are in question the candle-power and the lamp will naturally change with the quality of the mantles used, and consequently the illumination of the street will also vary. It is a well-known fact that the quality of the mantles, even of one and the same manufacturer, is not continuously the same, and the statement of minimum illumination might therefore be rather inconvenient in the case of gas lamps. Moreover, local conditions have to be considered, *e.g.*, in many cases the height of the lamps is restricted and existing lamp posts must be used. The natural thing would be of course to demand a certain proportion between minimum and maximum illumination, which should be kept as low as possible.

3. If illumination is to be measured this ought, in my opinion, to be carried out both in a vertical and a horizontal plane at about 5 to 7 ft. above the ground. This is to ensure sufficient illumination to enable the public to recognize passers-by as well as signs on omnibuses, tram-cars, house doors, &c.

* *E.T.Z.*, April 14th, 1910.

4. If candle-power is to be stated in the specification, the mean lower hemispherical candle-power ought to be considered. The nature of the curve of light distribution, therefore, must also be borne in mind.

5. I am not in favour of measurements being taken when the lamp is in position, such tests never being reliable. For gas lamps the ever-changing quality of the mantles ought to be considered. Therefore all competitive lamps, electric as well as gas, ought to undergo laboratory tests, but under equally favourable conditions.

6. I do not think that the tests of the constancy of the candle-power ought to be prescribed, but it must be required that lamps shall not be materially influenced by changes of atmospheric conditions such as humidity, strong winds, &c.

7. I do not advocate the introduction of any stipulation regarding the efficient shading of the lamps with a view to the avoidance of glare, but the height above the ground of the lamps ought to be prescribed according to their candle-power. Experience in the City of Berlin teaches that 4,000 candle-power high-pressure gas lamps can easily be hung up at about 17 ft. above the ground without being a danger and inconvenience to traffic and pedestrians.

8. There is no need to prescribe any specific colour of the light, but a stipulation ought to be made that the light must be of a tint convenient to the eyes; lamps should be preferred which contain but little ultra-violet rays, as energy of this kind has been proved to be injurious to vision.

Prof. Dr. J. Teichmuller (*Karlsruhe*):—

I am in entire agreement with the recommendations of the Verband Deutscher Elektrotechniker, in the framing of which I collaborated, and am still doing so. I consider that the work of the Commission appointed to deal with this subject has been most carefully carried out.

I may add that practical experience of these recommendations has been so far quite satisfactory; as the current literature on the subject shows, they are rapidly becoming familiar to engineers, and receiving general recognition. These recommendations will be put forward at the next general meeting for final recognition. They have also been submitted to the Verein von Gas- und Wasserfachmännern for approval, but no official announcement on this point has yet been made.

It is surely very desirable that international acts on these points should be agreed upon; and if the time for this is not yet quite ripe, I still feel that we should keep this aim in view. It would be very gratifying if the German recommendations could be approved by the British authorities, and eventually adopted as the basis for agreement of this kind.

(We have also to acknowledge the courtesy of **Herr G. Dettmar** the General Secretary of the Verband Deutscher Elektrotechniker, kindly confirming this information.)

Among other communications on this subject we have also to mention that of **Prof. Strache** (*Vienna*), who writes: "The question of framing a standard specification seems to me to be of such importance that I intend to put it before a commission that is to be constituted for this purpose by the Institution of Gas Engineers in Austria-Hungary."

We hope to be able to receive further data from this source, and also from **Dr. H. Kruss** (*Hamburg*).

In order to enable readers the more easily to judge on what points there is substantial agreement, we have tabulated the views of the various authorities on the next two pages. It should, however, be recognized that in many cases it has only been found possible to express *qualified* approval or disapproval of the suggestions put forward. The table must therefore be given a broad interpretation, and in any case of doubt reference should be made to the actual text of the replies.

TABLE SUMMARIZING VIEWS OF AMERICAN AND CONTINENTAL AUTHORITIES ON STANDARD SPECIFICATIONS FOR STREET LIGHTING.

N.B.—The letters *a*, *b*, *c*, and *d* inserted in the column beneath the name of each authority indicate the corresponding suggestions in the list of queries (in the first column) which meet with his approval.

Re Framing Standard Specification for Street Lighting.	Bell.	Bloch.[1]	Bunte and Drehschmidt.
1. Ought the specification to contain a statement of: (*a*) The electrical energy or gas to be consumed: or (*b*) the amount of light provided; or (*c*) both energy or gas consumed and amount of light?	(*c*) Yes	(*c*) Yes	(*c*) Yes
2. Should the amount of light supplied be specified in terms of (*a*) the provision of a certain actual minimum illumination in the street; or (*b*) the provision of lamps of a certified candle-power?	(*a*) No (*b*) Yes	(*a*) or (*b*)	(*a*) Yes (*b*) No
3. If illumination is to be measured, should this measurement be carried out (*a*) in a horizontal plane at a stated height above the ground; or (*b*) in a vertical plane; or (*c*) in some other inclined plane such as 45 degrees? (*d*) Should both the mean and the minimum street illumination be measured and specified?	(*a*) Yes[2]	(*a*) Yes (*d*) Yes, also max.	(*a*) Yes (*b*) Yes[3]
4. If candle-power is to be tested in the street, should (*a*) the mean spherical or mean hemispherical c.-p., or (*b*) the c.-p. in several specified directions, be tested?	(*b*) Yes, 25° to horl.	—	(*a*) No (*b*) Yes
5. Should the contract demand (*a*) actual measurements in the streets or (*b*) only laboratory tests of the competing lamps previous to the acceptance of a tender, or (*c*) preliminary laboratory tests supplemented by periodical tests of the actual lighting conditions when the lamp is in position?	(*c*) Yes	(*c*) Yes	(*c*) Yes
6. Should any test of the constancy of the candle-power of the lamps be prescribed?	Yes	Not at present	
7. Do you advocate the introduction of any stipulation regarding the efficient shading of lamps, height above ground, &c., with a view to the avoidance of glare, such as is recognized to be dangerous and inconvenient to traffic and pedestrians?	Yes		
8. Should any specific colour of the light be prescribed? If so, how should this be tested?	No	,,	
9. What other clauses would you suggest being inserted?	See p. 412.	,,	

[1] Favours specification of *Verband Deutscher Elektrotechniker*, to which Prof. Teichmüller (see p. 417) also gives assent.

[2] In Europe. [3] In experimental not routine work.

TABLE SUMMARIZING VIEWS OF AMERICAN AND CONTINENTAL AUTHORITIES ON STANDARD SPECIFICATIONS FOR STREET LIGHTING.

N.B.—The letters *a*, *b*, *c*, and *d* inserted in the column beneath the name of each authority indicate the corresponding suggestions in the list of queries (in the first column) which meet with his approval.

Herzog.[5]	Millar.	Monasch.[1]	Ruml.	Sartori.[1]	Scholz.	Voege.[1]
—	(*a*) Yes (*b*) No (*c*) No[4]	(*a*) No (*b*) No (*c*) Yes	(*c*) Yes	—	(*c*) Yes	(*a*) No (*b*) No (*c*) Yes
—	(*a*) No (*b*) No	(*a*) Yes (*b*) No	(*b*) Yes	(*a*) Yes	(*a*) No	(*a*) Yes (*b*) No
(*a*) Yes (*d*) Yes	(*a*) Yes (*b*) Yes	(*a*) Yes (*b*) No (*c*) No (*d*) Yes	(*a*) (*b*) (*c*) (*d*) No	(*a*) Yes	(*a*) Yes (*b*) Yes	(*a*) Yes (*b*) No (*c*) No (*d*) Yes
—	(*a*) No (*b*) Yes	(*a*) M. Hem. C.-P. (*b*) No	—	Neither	(*a*) M. Hem. C.-P.	(*a*) M. Hem. C.-P.
(*c*) Yes	(*c*) Yes	(*a*) No (*b*) Yes (*c*) No	(*b*) Yes	(*a*) Yes	(*a*) No (*b*) Yes (*c*) No	(*c*) Yes
—	Yes	No	—	—	No	No
—	No	No	Yes	—	No	Yes
—	No	No	—	Yes	No	No
—	See p. 415.	—	—	—	—	—

[4] Stated type of lamp with specified consumption preferred.

[5] Approves method adopted in Budapest. See Jehl, *Elec. World*, 1909, p. 986.

Notes on Illumination by Gas and Electricity.*

A PAPER on this subject was read before the Junior Institution of Engineers (London) on May 10th, 1911, by Mr. F. J. Hawkins. The author dealt in a general manner with the chief recent advances in gas and electric lighting, and briefly reviewed a few special problems, such as the lighting of streets, shops, private houses, &c.

Mr. Hawkins laid special stress on the importance now attached to avoiding "glare" and to the value of shades and reflectors as a means of screening illuminants and directing their light where needed. In this connexion he referred to the interesting work of Mr. A. J. Sweet, who had analyzed the requirements of street lighting, and shown how absence of glare was compatible with uniform illumination. To achieve this result he designed a special combination of Holophane reflector and opal outer globe. The principle that every source of light is incomplete without an appropriate shade or reflector is now being generally appreciated; Mr. Hawkins mentioned the Excello Dioptric Globe, and the Peard reflector used with the Oriflamme arc lamp, as illustrations of this tendency; the Greyson de Schodt reflector for inclined incandescent gas mantles in street lighting was also interesting.

In dealing with shop lighting Mr. Hawkins laid stress on the desirability of illuminating the goods by concealed lamps, and contended that outdoor brilliant lights were unnecessary. Turning to domestic lighting he pointed out that consumers are often reluctant to alter the positions of lamps and disturb existing arrangements. Consequently it is often only by effective shading and direction of light, or by introducing new types of lamps, that substantial improvements can be made. Mr. Hawkins also referred to the effect of wall papers on interior lighting, and gave a table of reflective powers of different materials. In conclusion he referred in complimentary terms to the work of the Illuminating Engineering Society.

The discussion which ensued was opened by Mr. P. J. Waldram, who referred to recent advances in illuminating engineering. Mr. Haydn T. Harrison made a few remarks on the nomenclature adopted by the author, and referred to the need for better illumination in side streets. Mr. K. Edgcumbe gave some additional illustrations of the effects of glare. Mr. W. J. Liberty suggested that the height recommended for street lamps, 30 ft., was more than would often be necessary. He also commented on the value of centrally placed sources at points where four roads converged; this had often enabled a considerable saving to be made, since the smaller lights in the side streets near this point could be extinguished.

Mr. J. S. Dow, agreed that the illumination of the goods in the window in shop lighting was the chief essential; he thought that Mr. Hawkins had rather overlooked the advertising value of outside lamps, although they should be properly arranged to avoid glare.

Mr. T. E. Ritchie dealt mainly with arc lamps and the advantages of indirect lighting; he thought that up-to-date firms were now alive to the importance of distribution of light from sources as well as intensity.

The Chairman (Mr. B. E. D. Kilburn), in proposing a vote of thanks to the author, expressed his sense of the value of such papers as this dealing impartially with various illuminants, and referred to the vast field which problems in lighting now presented.

* Paper read before the Junior Institution of Engineers, London, on May 10th, 1911.

Illuminating Engineering in Cinematograph Work.

By an Engineering Correspondent.

In considering the operations which take place in the ordinary cinematograph display one cannot but be struck by the scope for improvement in the scientific application of light for the purpose in view. We now recognize the fact that even the most modern illuminants are very far from perfection as producers of light; the best of them are said only to radiate about 5 per cent of the energy given to them in a useful visible form.

But when we come to consider the *application* of the light so obtained, the waste is often equally striking. How much of the light actually generated in the lantern for a cinematograph display, for example, is actually used in an effective way on the screen?

Before referring somewhat more fully to this point, however, it may be mentioned that there seem to be quite a number of illuminants to select from for lantern and cinematograph work. The cost of a number of these was considered in a recent contribution to the *Revue des Éclairages* (March 15th, 1911), and it may be of interest, in passing, to give some of the results put forward in this article. The illuminants considered included petrol, and spirit (used with an incandescent mantle), and the acetylene flame, and the oxy-ether, oxy-hydrogen, and oxy-acetylene flame used in conjunction with a pastille of incandescing material. It may be added that the use of liquid acetylene, although very convenient, is regarded as too expensive in comparison with the use of a generator for ordinary continuous work; but it might often be used with advantage for a temporary installation, in an emergency, or where cost is not a serious item. The author, therefore, based his calculation on the assumption that a generator and a special variety of carbide termed "Delta" were used. In the article referred to certain assumptions regarding the cost of petrol, spirit, mantle, and renewals, &c., are stated, but on this occasion we may confine ourselves to the final results given. These are as follows:—

Nature of Illuminant.	Candle-power.	Approximate Cost per hour (Shillings and pence).	Cost of 1,000 C.-P. hrs. (Shillings and pence).
		s. *d.*	*s.* *d.*
Petrol (with incandescent mant'e)...	60	0 2½	3 5
Spirit „ „ „	160	0 2½	1 4
Acetylene Flame	230	0 2½	0 10½
Oxy-ether (with incandescent pastille)	1,200	0 11½	0 10
Oxy-hydrogen „ „	3,000	3 2½	1 0½
Oxy-acetylene „ „	610	0 8½	1 2½
„ „ (with incandescent pastille and mangin mirror)...	3,900	0 8½	0 2

It is interesting to form a rough comparison with the cost of electric arc lighting which is very commonly used in this country. In general the price of current for working bioscope shows can hardly be less than 3*d.* a unit, seeing that the show usually takes place about the time of "peak" load. When the voltage exceeds 110 a motor-generator is usually employed to reduce the P.D. to about 60 volts; however, the arc is sometimes run in series with a resistance even on 230 volts, but usually only in the case of temporary shows. The following curve indicates roughly the current required for screens

of different area; it can only be regarded as approximate, and possibly many operators would obtain less favourable results.

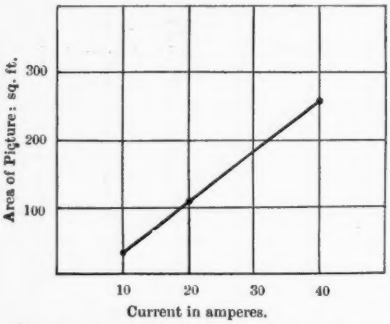


FIG. 1.—Showing current required to project cinematograph pictures of various sizes. The screen consists of white linen against a dark background, and the illumination is 2 foot-candles

When alternating current is available a transformer may be used, but it is well known that an alternating current arc is not so suitable for projection, and is inclined to be noisy and unsteady.

Under these circumstances the cost of electrical energy and carbons, in one case in which a picture about 18 ft. by 14 ft. was required, was found to be 1*s.* 1½*d.* per hour.

Such an arc lamp should yield about 2,500 m. sph. c.p., so that the cost per 1,000 c.p.-hours would work out to about 5*d.*

However, it must be recognized that it is difficult to make comparisons between different systems because there is scope for wide variation not only in the assumed cost of materials, but also in the method of expressing the candlepower. For example, the question might well be raised whether the candle-power of the various illuminants shown in the table from *The Revue des Éclairages* were measured and expressed in identically the same manner, and what allowance, if any, for the use of special mirrors or reflecting surfaces behind the actual source was made. It will also be observed how great a difference was apparently made in the result obtained from the oxy-acetylene apparatus with and without the mangin mirror.

Strictly speaking, one would suppose that the best method of all of comparing results with different systems would be to state the cost required to illuminate a screen of given area with a certain surface-brightness.

In the case noted above, the surface-brightness of the screen was 2 foot candles; in another bioscope show visited by the writer, it was only 1 foot-candle; and probably a series of visits to different places in London would reveal the fact that the standard of brightness varies considerably.

This leads us to return to the question raised at the commencement of this article regarding the possibilities of great economy in the *use* of the light, quite apart from the relative cost of the illuminant used. It is evident that by ordinary projection methods the percentage of the light generated in the lantern which is actually utilized on the screen is very small. Assume, for example, that a screen of 250 square feet in area receives a uniform illumination of 2 foot-candles. Then the flux of light given to the screen is 250 $\times$ 2, that is 500 lumens. If, therefore, we could spread *all* the light from a given source evenly over this screen without loss we should only require this source to have a candle-power of 500 $\div$ 4π, *i.e.*, about 40 candle-power. Yet the arc light actually employed to secure this illumination will often be found to produce as much as 1,000 candle-power, or more.

But, even having assumed that the light is as efficiently directed on the screen as possible, there remains the question, how much of the light reflected *from* the screen is usefully employed. If an ordinary white screen is used, it is, of course, evident that the picture will be visible from other directions besides those possible for the audience. For example, it could be seen from the roof, thus showing that a considerable amount of light is allowed to escape in that direction, and is therefore useless from the point of view of the audience.

This is a point which has been realized by those interested in cinematograph

shows. It may be observed that in general a long narrow room is used so that light reflected sideways and upwards is practically wasted. Attempts have therefore been made to secure surfaces which, instead of diffusing the light in all directions according to the cosine law, would send most of it straight back to the audience. For example, powdered aluminium screens, sometimes rippled or provided with minute ridges were employed. Some tests on such surfaces were recently referred to in *The Illuminating Engineer*.* It was shown that in some cases the brightness of the picture, with a given illumination, was 13 times as great as that secured with a screen of the ordinary white diffusing variety. On the other hand, the light under these conditions is reflected back over a much smaller angle, so that people looking slightly obliquely at the screen would not see the image at all. The method can therefore only be conveniently applied in cases in which a long narrow room is used. Conditions intermediate between scattered and regularly reflected light appear to be secured by the use of these metal screens.

These few remarks are intended merely as suggestions which might be followed up with advantage. For it seems clear that a substantial improvement in the method of directing the light would enable lamps of smaller power to be used, and would often lead to economies quite as great as those secured by the use of a more efficient illuminant.

* Vol. iii., 1911, p. 133.

The Educative Value of Technical Journals.

COMMENTING on the means of education at the disposal of the young engineer of to-day *The Gas World* remarks: "In regard to the knowledge of gas supply technics, this can only be acquired by working at them, and reading the technical journals. There are books, of course, which are helpful so far as they go; but except where they rightly treat of permanent principles, text-books are no sooner printed than they go out of date. The technical journal is the best instructor; and the pity is that so many young men neglect this means of instruction."

The same might truly be said of illuminating engineering. Progress in this field is exceedingly rapid, and a journal which treats this subject adequately can naturally cover the ground and keep abreast of improvements in a way few text-books can do.

Illumination in Cotton Mills.

THERE is a natural demand for lectures before non-technical bodies, manufacturers, &c., dealing with the special branch of lighting in which they are interested.

A case in point is presented by a recent paper by Mr. J. S. Codman on 'Illumination in Cotton Mills,' before the National Association of Cotton Manufacturers in Boston (U.S.A.).

The paper appears to have dealt with the special difficulties which arise mainly through the intricacy of the operations and the necessity of avoiding inconvenient shadows. It is pointed out, for example, that it is difficult for the weaver to draw the thread through the dents of the reed in comparative darkness. In the same way a shadow is apt to be cast from the weaver's body as he alters his position. The question of the position of the lamps is here every whit as important as the amount of illumination, and no little skill is needed to avoid all objectionable shadows.

Notes on the Placing of Lamps.

By An Engineering Correspondent.

The correct location of lamps in any illuminating scheme is no less important a matter than the choice of suitable types and the use of appropriate globes and reflectors. The general condition to be fulfilled in most practical cases is the obtaining of uniform or at least equally graded illumination in sufficient amount, and the avoidance of direct incidence of light from the source on the eyes of persons moving in the area lighted. Physiological considerations must always be given first attention, artistic effects being usually of secondary (though sometimes great) importance.

Broadly speaking it is best for all *general* illumination to be derived from high candle power lamps placed high above the plane lighted, and preferably illuminating the latter indirectly (especially in interiors).

In the interiors of dwelling houses, public halls, and so on, indirect lighting is usually effected by placing tube or bulb lamps behind a deep, reflector-lined moulding near the ceiling, the illumination of the room being then by diffuse reflection from the latter. The low angle of incidence of the light from such lamps results in far less efficient reflection than is obtained in the case of ceiling illumination from pendant or bracket lamps (the coefficients of diffuse reflection varying from 60–70 per cent and 80–90 per cent in the respective instances). Though indirect lighting gives a most hygienic and satisfactory general illumination to a room, it is usually advisable (if only to give way to a common prejudice) to place a few well shaded bracket or pendant lamps about the room—any lamps required for extra local illumination being independently provided as usual.

Wherever bracket or pendant lamps are employed they should be arranged—when such a course does not interfere with the distribution primarily required from their globes or shades, nor yet enable direct vision of the source—to throw a maximum of light upwards on to the ceiling, thus aiding greatly in the general diffuse illumination of the space. If, however, the lamps are near the ceiling, such an arrangement may lead to unequal brilliancy or "streakiness" of the ceiling (above all to be avoided) unless diffusing screens are interposed.

The painstaking principles which have become so widely accepted in illuminating engineering may often lead to wholesale variations in the proposed position of lamps in order to make better use of particular surroundings. In many instances the utilisation of natural, or rather existent, surroundings, instead of the entire provision of artificial diffusing media (globes, reflectors, &c.), leads to results so much better and more artistic as to compensate fully for additional trouble and outlay on the former scheme.

Special globes and reflectors, to whatever service applied, often need to be used at special heights and always with a distinct recognition of the particular distribution they are intended to give. In elaborate illuminating schemes these accessories are individually designed to take account of the special precincts in which they will be used, so that they may vary the primary distribution of the lamps to obtain the most effective assistance from their surroundings.

Similarly, though to a less extent, special lamps need special conditions. Flame arcs, for instance, should be as high slung as possible, while, in interiors, tube lamps are best placed at a considerable height, alike to secure uniform

illumination and to avoid the necessity for screening globes.

Lamps shining on to dark patches of wall or out through clear unshaded windows, are not only inefficiently placed,* but also appear in unnecessarily exaggerated contrast with their background. This applies alike to domestic and to workshop lighting. In the former it is usually easy to find a better location for the lamp than opposite a window, or at least to screen the windows with diffusely reflecting blinds.

In workshop lighting, "general" lamps, necessarily high slung among the roof girders, often send a large percentage of their light directly out through adjacent skylights: this loss may be avoided by the use of "umbrella" reflectors immediately above the lamp, but, in almost every case, better results could be obtained by inverted lighting, the roof and its framework being whitewashed or white-painted and the skylights covered by dense white "blinds" pulled over them at dusk.

The high-placed "general lighting" lamps of workshops must be supplemented by much smaller local units having a candle-power and location chosen with due regard to the particular function they serve. Specially adapted globes or reflectors are usually desirable, and in the majority of cases the lamp should be fixed, or the workman will inevitably move it to secure the greatest possible intensity of local illumination, regardless of contrast and his neighbour's convenience, as of the harm he may be doing his own eyes by excessive glare.

Wherever local illumination is required the greatest care must be devoted to avoiding *excessive concentration* and *sharp contrasts*.

Street lamps should often be mounted higher than is general in English practice, though in this, as in other illuminating matters, great progress has been made during the past few years. By using taller poles, spaced further apart and correspondingly increasing the candle-power per standard, the resultant illumination is of improved uniformity, and is obtained at a less overall cost per annum. Central illumination is generally preferable for streets in which the necessary poles will not impede traffic, while in narrow streets, arch lighting may often be applied with pleasing and efficient results. For small towns the multi-light standards shown diagrammatically in Fig. 1 give

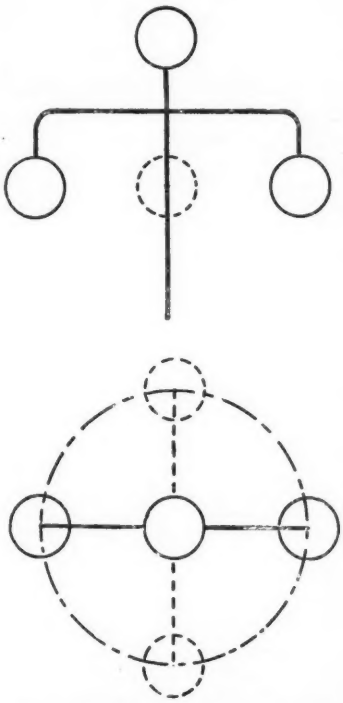


FIG. 1.—Sketch Plan and Elevation of Multi-light Standard.

excellent results, though rather costly to install. Three or five 100-watt metallic filament lamps are enclosed in separate diffusing globes, spaced so as to cover a 3 or 4 ft. circle. This arrangement, widely favoured in America, is superior (from the illuminating point of view) to the bunched clusters, contained in a single clear lantern, which are generally adopted in the medium-sized English provincial town.

* In special cases they may, however, be purposely so placed to fulfil some definite object.

Artificial Silk Mantles.

E. MÜLLER, in a recent number of the *Zeitschrift für Beleuchtungswesen*, gives some interesting photographs illustrating the qualities of artificial silk mantles as compared with those composed of cotton wool and Ramie fibre. Since the oxide used to impregnate these mantles is the same in each case, the chief difference in their luminous values must arise through the nature of the web. These micro-photographs, showing the web of the mantles, are magnified seventy-five times. It is pointed out that the artificial silk fibres are not only more regular, but are spaced some distance apart, instead of being massed together, and therefore give a greater luminous surface and more light. Some micro-photographs are also given showing the changes in the fibre after burning 250, 500, and 1,000 hours respectively, and it is contended that while the Ramie fibres at the end of this period appear torn and irregular when viewed under a microscope, the mantles of artificial silk appear scarcely altered. It is only recently that it has been found possible to make artificial silk mantles which will stand transport, but these difficulties are said to have now been overcome, and its superior qualities as regards elasticity and durability are claimed to render such mantles especially serviceable for high-pressure street lighting.

The Intrinsic Brilliancy of Opal and Frosted Globes.

AN interesting comparison of the intrinsic brilliancies of opaline and frosted or sand-blasted globes was recently published in *The American Gas Light Journal*. The projected surface of two 5 in. globes, one of each type, was divided into four zones, and the intrinsic brilliancy of each zone measured separately by means of screens inserted in succession over each region.

The results indicate a considerably greater brightness in the case of the frosted globe. The brilliancy of the opaline globe, on the other hand, is much the more uniform of the two, only varying from two to just over three candles per square inch in the various zones, whereas the extreme zones of the frosted globe give one and ten candles per square inch respectively; also in this latter case, a bright spot in the centre is quite noticeable.

Schoolhouse Lighting Inspection in Boston.

WE notice that in the course of a recent meeting of the New England Section of the Illuminating Engineering Society (U.S.A.), a visit of inspection was paid to one of the evening schools of Boston, under the guidance of Mr. B. B. Hatch, illuminating engineer to the Boston School Committee.

Mr. Hatch made special reference to the question of wall decoration, where some care is necessary to maintain the balance between illumination requirements and artistic effect. For example, some special styles of decoration introduced by the Civic Art League of Boston have been of such a dark tint as to prove inconvenient in lighting.

The selection of appropriate shades for the windows is also receiving attention. It is stated that about 6,000 dollars is now being expended on improvements in illumination in schools in Boston.

Illumination from the Standpoint of the Chemical Engineer.

A LECTURE, entitled 'Progress in Modern Illuminants and their Industrial Applications,' was delivered by Mr. L. Gaster at the Exhibition of Applied Chemistry (held at the Agricultural Hall, London) on May 22nd, 1911, Mr. Walter Reid, F.I.C., F.C.S., being in the chair.

The first part of the lecture was devoted to the part played by the chemist in the development of new methods of lighting. It was pointed out how chemical research had been active from the first in connexion with petroleum, acetylene, and gas lighting, and that the incandescent mantle, was substantially a chemical invention. In the same way, in electric lighting, the details of manufacture of metallic filaments and arc-lamp electrodes involved abstruse chemical problems, and the chief reason that we had waited so long for these innovations in this field had been that the difficulties in the preparation of the required materials in a pure state had only recently been completely overcome.

Proceeding, the lecturer remarked that chemists and chemical engineers, besides being interested in the manufacture of illuminants, were also intimately concerned with the effects of light. For example, the fading of colours of dye-stuffs, due to ultra-violet rays, was an important problem, and there were many special departments, such as silk and dyeing works, the manufacture of perfumeries, flour mills, &c., where a light approximating in colour closely to daylight was most essential. The same might be said of the chemical laboratory where delicate colour tests were often employed.

Mr. Gaster then alluded to some recent attempts to produce an artificial light resembling daylight. For example, the carbon dioxide Moore tube was said to be good in this respect; more recently Dr. H. E. Ives, in the United States, had designed a special screen which, when placed in front of the tungsten lamp, absorbed such colours as to cause the transmitted light to be almost exactly equivalent to normal daylight.

But, apart from these special applications, managers of chemical works were directly interested in the general provision of good illumination. Cleanliness in chemical operations was recognized to be very essential, but it was hardly possible to secure good conditions in this respect without good illumination. In the same way poor lighting paved the way for accidents, and interfered with the speed and certainty with which delicate operations could be carried out, thus leading to a considerable loss in efficacy and output. In general the cost of adequate lighting was small compared with the benefits in this respect which it secured.

In conclusion, Mr. Gaster emphasized the fact that the conditions of lighting required in chemical works are often of a special character. For example, a steam-laden atmosphere may prove most detrimental to some systems which would be quite satisfactory under normal conditions, and the presence of acid and alkali fumes, &c., often led to inconvenient effects on piping, insulation, &c. It was also essential for the lighting engineer to study the special processes carried on in the premises to be illuminated, and to know how to arrange the lights so as to be of greatest assistance. He therefore held that the specialist who dealt with such matters, besides understanding illumination should have some special knowledge of chemistry. All this he mentioned merely to illustrate the importance of good illumination in chemical works; he hoped that chemists, who had done so much in con-

nexion with the invention of illuminants would also take a more direct interest in their industrial applications.

At the conclusion of the lecture a series of slides were thrown on the screen illustrating the applications of various systems of lighting by gas, oil, acetylene, and electricity in factories.

The Perception of Light and the Sense of Colour.

Two recent papers read by Dr. F. W. Edridge-Green before the Royal Society (June 30th, 1910), and the Phys. Section of the British Med. Association, in the same year, have an interesting bearing on the principles of colour perception.

The first of these papers contains particulars of tests by the spectrometer method on a variety of colour-blinds. It has often been pointed out that tests of colour-blind people, which ought to afford *confirmation* of a correct theory of colour-vision, often yield results which it is extremely difficult to reconcile with the older theories. Dr. Edridge-Green lays stress on this point, and has come to the conclusion that it is only by discriminating between the power of distinguishing colour and the capacity to see light that consistent results can be obtained. Thus a shortening of the spectrum at one end may coexist with normal powers of analyzing colour, and may interfere very little with the general perception of shade. Again, it is difficult, except by separating the senses of light and colour, to explain the variation in the luminosity curves of different colour-blinds; in some cases the curves resemble those of ordinary vision, in others they are quite peculiar. A. Koenig, for example, has pointed out that, even in the case of people credited with normal vision, considerable variations in this respect exist, while one so-called "green-blind" had almost the same curve as himself and a normal sighted woman.

The second paper deals with another item in Dr. Edridge-Green's work previously referred to in this journal, namely, the suggestion that visual purple is not non-existent in the "yellow spot" on the retina, as was recently supposed, but can find its way in between the cones. All the peculiar phenomena connected with the behaviour of the eye at low illuminations, previously explained by crediting the rods and cones with distinct functions, are, on this theory, due to the ebb and flow of the visual purple towards the central region of the retina.

This paper describes a new method of actually demonstrating the movements of the visual purple. After gazing a moment through certain colour solutions and then shutting the eyes, an image of the yellow spot becomes distinctly visible. Again (as was long ago discovered by Purkinje), if light is concentrated on the eye while the subject looks at a dark background the vessels of the retina and the yellow spot can be distinctly perceived. Dr. Edridge-Green describes quite a number of methods of studying the eye in this way, and draws attention to a curious phenomenon thereby made visible, namely, the presence of "whirling currents" apparently revolving around the yellow spot, and altering according to the nature of the illumination. These he suggests are not due to the circulation, but are actual streams of visual purple flowing into the fovea. Those interested should read Dr. Edridge-Green's paper for fuller details of these effects and how they are produced. They may possibly also prove of value in affording information on some obscure points in photometry and also as indicating a possible means of studying the influence of glare.

Short Notes on Illuminating Engineering.

From all Sources.

Light as a Preservative of Health.

HUMAN beings immured in darkness for any length of time lose weight and strength, and become pale and blanched like an etiolated plant. We have only to contrast the people who are in "populous city pent," dwelling in narrow streets, in dingy courts, in tenebrous tenements or Cimmerian cellars, and working in dusky shops and factories, with those who labour in the fields under the vault of the blue sky, and shelter in cottages or in hovels, it may be, but open to the weather, bathed in all the sunshine that our climate affords, in order to realize that light is salutary and darkness deleterious....The blind are almost invariably feeble, anæmic, and prone to illness. No doubt other concomitants of their affliction are partly responsible for their debility, but the deprivation of trophic influence which their sightlessness involves is, I believe, its chief cause.—SIR JAMES CRICHTON-BROWNE, in the *Windsor Magazine*, May, 1911.

Automatic Control of Motor Lamps.

WE notice in *The Acetylene Journal* mention is made of various devices now being introduced for the control of acetylene headlights on motor cars. The general plan is to use electricity for lighting the lamps from the chauffeur's seat, thus avoiding the necessity of stopping the car in order to attend to the lights.

An Ornamental Gas Lighting Standard.

THE street lighting standard illustrated below is of a somewhat striking type, and considerably more artistic than some of those to be seen in our streets. It is of American design, fitted with inverted gas burners and opal globes.

By adding an upright fitting in the centre at the top, the standard can be arranged symmetrically for either two, three, four (as shown), or five burners.

These standards have been used in America both with artificial and natural gas.

A Lighting Department on British Railways.

DURING recent years British railways have developed a preference for entrusting all matters connected with lighting, whether of rolling stock, signals, or stations, &c., to a special department, presided over by a lighting engineer, rather than have illuminating matters attended to by various departments without centralized control. From the economical standpoint, this policy has everything to recommend it. It secures greater efficiency at a lower expenditure, and the saving obtained through standardizing lamps, burners, incandescent mantles, and other fittings alone makes the establishment of a special lighting department worth while. One example of the value of such a department is that it can employ its own staff of maintenance men to inspect lamps and mantles, &c., and keep them in good condition, a system which is invariably found to produce more efficient, and at the same time more economical lighting. A railway covers such a wide territory, and its lighting installations differ so widely in size—from the requirements of a tiny country station to those of a great terminus, or an extensive range of workshops—that the absence of centralized expert control is bound to be wasteful. The British railway companies are the largest users of artificial light in the country, and as several of the big companies spend over £100,000 a year on their lighting bills, it will be seen that even a small percentage saving represents an appreciable sum.—*Financial Times*, May 15th, 1911.

The Lighting of Aquarium Tanks.

IN the article on the Lighting of the Horniman Museum in our last issue, some suggestions were made regarding the lighting of aquarium tanks, at least one light per tank being suggested as necessary. Since publishing the article we have received the report of the Museum, in which reference is made to some changes that have been recently effected in the lighting of this part of the Museum. A separate lamp is now provided for each of the large slate tanks, the switches being so arranged that the light for any tank may be turned on temporarily by the visitor pressing a button and holding it down, or for a longer period by the use of an ordinary switch placed above each tank.

This is an interesting example of the recognition of the necessity for special methods of illuminating exhibits, and it is stated in the report that these improvements have added greatly to the attractiveness of this section of the Museum.

The "Conservation of Vision."

"THE 'Conservation of Vision' is to-day as new and vague a phrase as illuminating engineering was five years ago, but its import is no less important to the general public. Briefly stated, the conservation of vision movement is the culmination of a number of separate efforts which sprang up simultaneously in different fields, having the same general purpose of protecting and conserving the organs of vision.

"Illuminating engineering....originated from economic motives. The gross and needless waste of illuminants in producing illumination attracted the attention of those who were dealing with other scientific problems, and resulted in a study of the subject on engineering lines....

"On the other hand, the fact that a very considerable portion of the total blindness in existence was due to preventable causes set those who deal with the physiological side of vision, and others who were interested purely from the humanitarian side, to thinking upon the question of the value of vision and its proper conservation....

"The interest thus aroused in the subject of lighting entirely from the physiological standpoint, and as affecting the user of light....has resulted in what is aptly called the conservation of vision movement."—E. L. ELLIOT in *The Illuminating Engineer* (U.S.A.).

Poor Illumination Causes Mishaps.

Our attention has been drawn to a case in which defective lighting was responsible for damage done to an article of clothing which was going through the usual process of cleaning at a large dyeing and cleaning works. It appears that a costly silk dress was scorched by being treated with too hot an iron, and the accident was all the more surprising in view of the fact that the girl operator was an expert in the work. Several other mishaps occurred during the day, but it was only later that the explanation was realized. It was found that the lighting plant of the factory had been temporarily defective, with the result that the illumination must have been considerably below the proper value.

Every Electric and Gas Supply Company should have a Lighting Expert.

We are very careful about our installations. First to see that the right kind of lights go into a merchant's store, and that the light is properly distributed. Second to see that the fitter does his work as neatly as possible. We have one man, who has given this line of business very careful study, to whom all these questions are referred. By this method very few mistakes are made on installation and the merchant is assured of highest efficiency at least possible cost.... While it may not be possible for every company to employ a lighting engineer, they should at least have one man to whom all lighting questions can be referred and who can recommend the light best suited for the particular place. Above all, they should give good service. *Good service costs money, but it pays in the end.—J. N. Cooke,* '*Progressive Age*,' *May* 15, 1911.

Illuminating a Church Spire.

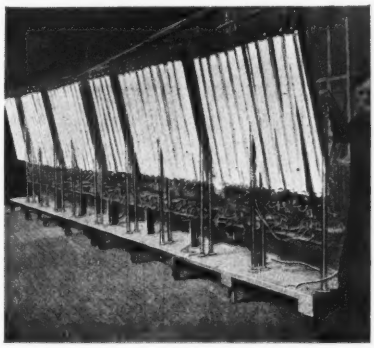
The cross on the spire of a Catholic Church in Chicago has recently been illuminated in outline by a large number of low candle-power glow-lamps, and is now visible at night for a considerable distance.

Mercury Vapour Lamps in a Moving Picture "Studio."

The remarkable development of the picture theatre has produced a demand for films not only of a varied and striking character, but of a high degree of finish, both in the acting of the scenes and in the quality of the photography.

The illustration shows an installation of mercury vapour lamps for the illumination of stage settings in the "studio" of an American firm, which produces very elaborate films.

Reference was made recently to the use of mercury vapour lamps for the production of cinematograph films in a paper by E. L. Simons in the *Transactions* of the American Illuminating



Engineering Society.* It was there pointed out that owing to the unreliability of daylight, artificial illumination was very largely employed by film makers, and furthermore, that the monochromatic rendering of colours is most satisfactorily achieved by the mercury vapour lamp.

According to *Popular Electricity*, in some of the moving picture studios the salaries of the actors alone may in some cases run to several hundred dollars a week, and under these circumstances it is not surprising that considerable outlay is devoted to getting the best possible lighting effects, and ensuring good results from the photographic point of view.

* April, 1911, p. 295.

Decorative Lighting in Schools.

An interesting example of decorative school lighting is furnished by the illustration below. This represents a recent installation of the A. E. G., and was described in the *A.E.G. Zeitung*, to the courtesy of whose editor we are indebted for the use of this picture.

In many of the schoolrooms, especially the larger ones, inverted arclighting has been employed. In cases where the supply is alternating a mercury vapour rectifier is also frequently installed so as to provide a unidirectional current for lantern work, &c.

The hall shown in the illustration is of a somewhat different kind. It is used mainly for concerts and on festive occasions, and therefore a more cheerful decorative style of lighting was selected. The main effect is the use of ornamental lanterns supplemented by hanging metallic filament lamps, which, however, are placed comparatively high up out of the field of view.

Improvements in the Neon Tube.

M. Georges Claude has, according to a note in *L'Électricien*, been able to modify the neon vacuum tube so as to dispense with the arrangement for compensating for the gradual absorption of the neon. The tube will last for a considerable time without requiring renewal, and the whole arrangement is much simplified. Moreover, it is possible to produce tubes only 5 or 6 metres in length, which can be transported from the factory, installed, and renewed when necessary much more readily than the tubes previously employed.

Badly Placed Lights Cause Sleepiness.

American oculists have so many patients who, even with the best spectacles, cannot escape suffering whenever they go to the theatre or opera, &c., that the term "panorama headache" has come into general use.

One of the most common symptoms of eyestrain, known to all oculists, is sleepiness when reading by artificial light. This is certainly partly due to unhygienic qualities in the system of illumination used.—*Dr. G. M. Gould, Illuminating Engineer (New York), June*, 1911.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Portable Acetylene Lights and Country House Installations.

WE have received from **Messrs. Carbic, Ltd.** (27, Cannon Street, London, E.C.), an illustrated price list of Wakefield's Patent PORTABLE ACETYLENE LIGHTS, manufactured by them. These are made in a variety of sizes, from a small hand lamp up to a flare light of 3,000 C.P. Several examples are mentioned of the application of these lamps for emergency lighting, including their use on a bowling green, to which we have previously referred in this journal.*

We have also received a list dealing with acetylene apparatus for COUNTRY HOUSE LIGHTING, and a short pamphlet describing the Carbic OXY-ACETYLENE WELDING PROCESS.

"Dial" Fuses.

The Electrical Co., Ltd. (122–24, Charing Cross Road, W.C.), have sent us a price list and fully illustrated description of their "DIAL" FUSES. The principal advantages claimed for these fuses are: (1) safety, due to the live parts being enclosed and the molten fuse wire remaining in the cartridge after the fuse has blown; (2) prevention of over-fusing circuits by making the diameter and length of the cartridge correspond to a given capacity, so that two fuses of different capacity will not be interchangeable; (3) extreme clearness of the indicator or "dial" in the front, which shows when the fuse has blown and also indicates the capacity and the voltage of the circuit.

THE **A.E.G.** (Berlin) send a small pamphlet describing a MERCURY RECTIFIER designed specially for use with cinematograph and other arc lamp projectors.

* *Illum. Eng.*, London, vol. iv., Mar., 1911, p. 181.

Suspension Fitting for Holophane Reflectors.

THE "SAMSON" SUSPENSION for use in connexion with Holophane reflectors is shown in the accompanying illustration. It is being put on the market by **Messrs. Siemens Bros., Dynamo Works, Ltd.**, and is substantially designed so as to form

a thoroughly reliable suspension. The ceiling-plate can be supplied either to fix direct to the ceiling or to cover conduit boxes or ceiling-roses.

The fitting has been designed for use in conjunction with the STILETTO type of Holophane Reflectors.

"Tubolite" Metal Filament Lamps for 125 Volts.

WE are informed by the **Linolite Co., Ltd.** (25, Victoria Street, London, S.W.), that they are now prepared to supply METALLIC FILAMENT TUBOLITE LAMPS up to 125 volts, the candle-power being 12 and the efficiency about 1·5 watts per candle. The price of the new fitting complete will, we understand, be the same as that of the present 25-volt range.

Brimsdown Lamp Works—Annual Outing to Hastings.

THE **Brimsdown Lamp Works** held their third annual outing on Saturday, June 3rd, when a party of over 500 were conveyed by special train to Hastings. Mr. E. Scharrer, the General Manager, presided over the dinner, which was held in the Royal Concert Hall, and he was supported by Mr. J. Chiswell. In addition to the loyal toasts, "Success to the Brimsdown Lamp Works" was proposed and responded to with enthusiasm.

It is evident from the success of the trip that those who are responsible for the good organization of the Works (to which we referred when describing a visit to Brimsdown in our February issue) are equally capable of arranging a very enjoyable outing.

New Electric Travelling Facilities.

The British Electrical Federation, which comprises numerous tramway and electric supply undertakings in Greater London and the provinces, has been making inquiries extending over some months regarding "trackless trolley" methods of construction by means of which electric omnibuses are put in service to be driven by current taken from overhead wires. It is hoped that in this manner improved traffic facilities may be provided in rural and extra-suburban districts, which would not justify the greater expense of laying tramway rails.

Messrs. Wm. Geipel & Co. (St. Thomas Street, London, S.E.) have sent us a list of ARC LAMP CARBONS, manufactured by Fabius Henrion, for which they are the British agents. The list is an extensive one, covering all ordinary varieties of carbons, as well as some for special purposes such as cinematograph projectors and electric welding apparatus.

New "Onewatt" Lamps.

Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen Street, Dalston, London, N.E.), are, we are informed, now placing on the market a range of 50 C.P. (55 watts) drawn tungsten lamps for high and low voltage circuits. These lamps will be of the same quality as the other types of "Onewatt" lamps, and will be supplied in bulbs of the same size as "Tantalum" lamps of the corresponding voltages and candle-powers.

Transformers for Metal Filament Lamps.

Messrs. Siemens Bros. have also sent us a leaflet giving particulars and prices of Transformers for Metal Filament Lamps. The list contains a wide selection of Auto-Transformers, Double Wound Transformers and Bell Transformers, and Messrs. Siemens mention that they will be pleased to quote on inquiry for any type of transformer not included in the list.

A Table of Electricity Works in Austria.

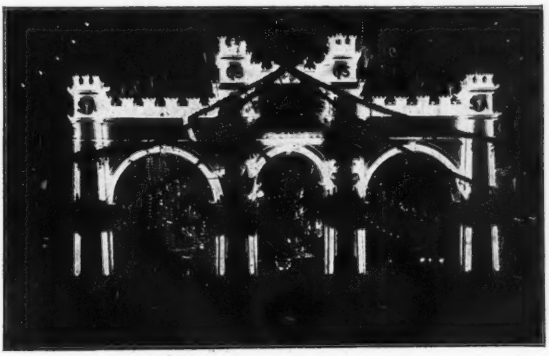
IN view of the growing number and importance of the Electric Supply Installations in Austria, the **Elektrotechnische Verein** (Theobaldgasse 12, Vienna, VI.) inform us that they have in preparation, and will publish on July 1st, a list of 800 SUPPLY UNDERTAKINGS IN AUSTRIA AND BOSNIA-HERZEGOVINA. The book will give full details of capacity of plant, voltage, and frequency of supply, system of distribution, &c., and it is to be issued at the price of K. 2.80, if subscribed for before publication; K.3.80 afterwards. The work is being brought out with a view to assisting the development of the electrical industry by putting before engineers valuable information in a cheap and convenient form.

Messrs. R. W. Paul (New Southgate, London, N.) send us some abbreviated lists of ELECTRICAL MEASURING AND TESTING INSTRUMENTS, particularly those which make use of the "Unipivot" moving-coil principle, which has been developed by this firm.

Messrs. E. & F. N. Spon, Ltd. (Haymarket, London, W.C.), send us a preliminary announcement of a book shortly to be issued entitled 'Bibliographical History of Electricity and Magnetism,' by Paul F. Mottelay.

Illumination Effects.

CARBON filament lamps have been in considerable demand during the recent Coronation celebrations, as the temporary nature of the installations would not admit of the higher priced metallic filament lamps being widely used. The accompanying illustration shows some effects that were obtained with carbon lamps in illuminating an arch during the Royal visit to South Africa on the occasion of the opening of the Imperial Parliament there. Many thousands of lamps were supplied for these decorations by the South African branch of Messrs. Siemens Bros. Dynamo Works, Ltd., who, we understand, have used similar lamps in their various Coronation schemes. Among which may be mentioned several branches of the Royal Mail Steam Packet Co., The Commercial Union Assurance Co., Carreras, Ltd., Kensington Town Hall and Library, various branches of Messrs. Williams Deacons Bank, &c. In each case the work was sub-let to local contractors.



Some Publications Received.

Chromatic Aberration and Visual Acuity. By Dr. Louis Bell.—A reprint of an article appearing in *The Electrical World* (May 11th, 1911), in which the author shows that a gain in visual acuity might be expected by obtaining as nearly monochromatic a light as possible, and gives some results showing the effect of reduction of chromatic aberration by this means in the special case of the mercury-vapour lamp.

Annual Report of the Horniman Museum and Library, 1910.—This contains a reference to an improvement in the lighting of the Aquarium gallery (see p. 430).

Eighth International Congress of Applied Chemistry, September, 1912.—We have received a preliminary announcement of the above, including a list of official representatives in various cities, and details of the sections and sub-sections into which the Congress is to be divided.

An Enquiry into the Hygienic Conditions of the Printing Industry in Italy. By Dr. Luigi Carozzi. We notice among the subdivisions of the enquiry, one dealing with illumination, natural and artificial, and with photometry.

Lectures on Illuminating Engineering.—The official report, in two volumes, of the Lectures delivered at the Johns Hopkins University, Baltimore, in October and November, 1910, under the joint auspices of the University and the American Illuminating Engineering Society. These lectures cover the whole field of illuminating engineering and the clear and compact form in which they are now issued, should form a standard work on the subject.

Principles and Design of Exterior Illumination. By Dr. Louis Bell.—Two lectures reprinted from the above. Lecture I. deals mainly with general principles, whilst the second lecture is devoted to street lighting.

The Physical Characteristics of Luminous Sources. By Dr. E. P. Hyde.—A reprint (from the above report) of two lectures dealing with Radiation and Luminous efficiency, first in a general manner, and secondly with special reference to various types of incandescent and arc lamps, mantles, &c.

Among other publications we have also to acknowledge the receipt of the following: *Transactions of the Illuminating Engineering Society (U.S.A.), The Journal of the Royal Society of Arts, The Journal of the Society of Architects, Transactions of the South African Institute of Electrical Engineers, Journal of the Western Society of Engineers, Proceedings of the Tokyo Mathematico-Physical Society.*

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

Among articles in the American press we may note several recent contributions to *The Electrical World*. Thus Cravath (*Elec. World*, N.Y., May 25) deals with **Simple Methods of Calculating Illumination**; he points out that the ratio of the flux usefully employed on the working plane to the total flux generated may vary within wide limits—from 65 per cent down to 10 per cent—and in all lighting problems empirical rules must therefore be applied *only* after taking strict account of the local conditions.

The same authority has also been lecturing on the **Illumination of Cotton Mills** (*Elec. World*, N.Y., May 18) where the question of the avoidance of objectionable shadows is a very serious one. Yet another interesting note in the same journal refers to an **Inspection of the Lighting Conditions in Schools in Boston**, where an illuminating engineer to the School Board has been appointed.

E. C. Crittenden (*T.I.E.S.*, May) makes some interesting comments on **Flame Standards.** He refers to the difficulty of reproducing the parts of the pentane lamp to standard dimensions; a gradual progressive change in candle-power on the part of new lamps has also been detected by some observers. He discusses the desirability of automatic control of the conditions of burning. Reference is also made to the Elliot oil standard, and a chart is given showing its variation in candle-power with different amounts of water vapour.

The article by S. W. Ashe contains a summary of much of the work done in Germany and elsewhere showing the connexion between **Illumination and Acuteness of Vision.** The experiments of Koenig, Uthoff, and others are quoted, and curves are presented showing how the power of perceiving detail improves with increasing illumination up to a certain point where glare begins. The article is commented upon in an editorial in the *Electrical World* (N.Y.).

A paper by N. J. Cooke (*Prog. Age*, May 15th) dealing with **Commercial Lighting** is of a readable character, and dwells upon the treatment of consumers, complaints, &c. Attention is called to the advisability of each company having at least one special expert thoroughly conversant with illumination.

E. L. Elliott (*Illum. Eng.*, N.Y., June) contributes an article entitled '**In Lightest New York.**' In this the methods of lighting the chief streets are described and illustrated by appropriate sketches. The same theme is treated by H. T. Owens (*Elec. Rev.*, N.Y., May 27th), who, however, dwells mainly on the designs of the lamp posts and columns.

In *The Electrician* the discussion on **Primary and Secondary Sources of Light** still continues; the subject is reopened by an article by Haydn T. Harrison, who suggests that a distinction should be drawn between sources which give sharp shadow and very extensive light-giving surfaces which presumably do not. A different view is taken by A. P. Trotter (*Electrician*, May 26); it is pointed out that there are few systems which are truly shadowless and that no sharp line of division of this kind can be drawn in practice. In his communication Trotter refers to a letter in *The Railway Gazette* by Roger T. Smith, who lays stress on the importance, in comparing different systems of lighting, of measuring illumination rather than candle-power.

Among other items passing reference may be made to the article in *The Progressive Age* by M. S. White, who compares the **Intrinsic Brilliancy** of sources covered by opal and frosted globes; he finds that the intrinsic brilliancy of the former is substantially lower, and that the brightness is also more evenly distributed. There are also various illustrated articles dealing with decorative street lighting, in which night views of illuminated façades and signs are given. The *Zeitschrift für Beleuchtungswesen* (June 10) contains a description of the "Holophane Lumeter" photometer.

Several of the British electrical journals also refer to the prize of £1,000 offered for an ideal form of miner's lamp, and the requirements with which this must comply have been now announced by the Home Secretary (*Elec. Times*, June 1).

There have also been several interesting contributions dealing with more general physiological points. For example, LUMMER (*J.f.G.*, June 10) works out the **Curve of Luminous Efficiency** throughout the visible spectrum by combining the luminosity curve for the normal eye with the distribution energy. He suggests further that such a curve might be applied to determine the temperature of incandescent substances once the curve of sensitiveness of the observer's eye is known.

T. THORNE BAKER, in a lecture before the Royal Institution (*Engineering*, June 16), describes some interesting experiments on the **Effect of Light of Different Colours on Bacteria**; some varieties of bacteria development can be stimulated by appropriate kinds of light, but retarded by others. For example, the fermentation of sugar is apparently assisted by exposure to red rays. Interesting analogies can also be drawn between the behaviour of the eye and the effects of coloured light on photographic plates; plates can now be obtained which are even sensitive to rays in the extreme red.

In *The Electrical Review*, N.Y. (June 3) there is also an account of the use of **Ultra Violet Rays for Sterilization, Bleaching, &c.**, and considerable progress has recently been made in this direction.

ELECTRIC LIGHTING.

There have not been many articles dealing with novel technical points in electric lighting. **Street Lighting** has received some attention, the articles by A. SCHEIBLE, which have been referred to previously, being continued in *The Electrical Review* (N.Y.). The same journal contains a tabulated list of the costs of electric street lighting in various towns in England. Another contribution on the same subject is that of L. CROUCH (*Elec. Rev.*, Lond., June 2, 9) who presents tables for the luminous efficiency, intrinsic brilliancy, and cost of various electric street lighting units, and also a diagram in which the polar curves of light distribution of a number of the chief types of lamps are collected.

Among articles on glow lamps we may note the description of the manufacture of **Small Lamps for Telephone Service** (*Elec. Rev.*, N.Y., May 27; *Elec. World*, N.Y., May 18). Carbon filaments are used, a current of 0.1 amp. and a voltage of 25 being aimed at. In order to obtain the resultant resistance of 250 ohms a filament no thicker than the human hair is needed. From the tests on record it would seem that such lamps can be relied upon to operate in practice for a long time, some having stood as many as 1,000,000 flashes since first installed. *The Electrical World* (June 3) lays stress on the important step taken in the manufacture of **Drawn Wire Tungsten Filaments** and the resultant advantages as regards strength and durability.

The Electrical Review, N.Y., has an article discussing the **Discolouration of Metal Filament Lamp-Bulbs**, for which there are several distinct causes; the rushing out of these lamps in large quantities has led to some want of care in avoiding these defects.

An interesting new form of arclamp for producing ultra-violet light is also described (*Elec. World*, N.Y., May 27). This employs an anode of refractory metal such as tungsten and a well of mercury as cathode. The result is said to be a highly efficient white light, which is very rich in ultra-violet rays.

GAS, OIL, ACETYLENE LIGHTING, &c.

The chief items of interest in this section have been several lectures and papers before technical institutions and societies, *e.g.*, those of BUNTE (*J.G.L.*, May 30) and GREBEL (*J.G.L.*, May 30).

The latter makes an interesting comparison between the merits of the **Inverted and Upright Mantles** for indoor and outdoor lighting. He is inclined to prefer upright mantles for many purposes. Figures are also presented suggesting that the comparative efficiency of the inverted mantle is only slightly better than that of the upright type, and that there are corresponding drawbacks as regards reliability and attention required; these views, however, are contested in a more recent number of *The Journal of Gas Lighting*.

F. GÖHRUM contributes an article describing the improved **Lighting of Stuttgart** by inverted high pressure gaslamps (*Jour. f. G.*, May 25th). The feature of the installation is the suspension of the lamps on wires crossing the street. This is illustrated by several views of the main streets of the town, and diagrams showing the methods by which such lamps are raised and lowered.

J. P. HANLON (*Prog. Age*, May 15) describes some handsome showrooms of the united gas and electricity company at Newark. A feature is the equipment of different floors for various purposes, and the special devices employed to show off various appliances, shades, and fixtures.

Most of the remaining articles deal with distant control apparatus, which continues to receive as much attention as ever.

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Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
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EDITORIAL.

A State Committee on the Hygienic Aspects of Lighting.

THE French Official Gazette *L'Officiel* for June 16th, announces that a Committee dealing with the Hygienic Aspects of Illumination has been appointed by the Minister of the Interior in France.

Readers will recall that a valuable report on this subject was issued in 1907 by the Conseil d'Hygiène de la Seine, in Paris. This report contained an excellent summary of the legislation of various countries on factory lighting and was subsequently reproduced in this journal.* The appointment of the present Committee therefore affords additional evidence of the keenness with which our friends in France are taking up this important question.

The objects of the Committee, as outlined in the announcement referred to, cover a wide ground, including the general effects of illumination on health, the framing of simple rules as to the best means of applying customary systems of lighting to various industrial operations, the nature and causes of short sight and impairment of vision, and their connexion with defective lighting conditions, the study of methods of measuring illumination, &c. In studying these different questions *conjointly* the Committee should accomplish much valuable work. In the past the difficulty has sometimes been that recommendations on lighting were made by those interested primarily in the physiological and hygienic questions, but without an adequate knowledge of the measurement of illumination or vice versa. We have always pointed out that such questions as these must be linked together and that, to be truly influential, a Committee should include among its members not only distin-

* *Illum. Eng.*, Lond., vol. ii, 1909, p. 319.

guished oculists and physicians, but also engineers connected with the various illuminants, experts in photometry, &c. It is therefore satisfactory to observe that this Committee receives the support of a number of prominent authorities on hygienic matters, gas and electrical engineers, inspectors of factories, and others interested in various aspects of industrial lighting.

The Committee should act as a most valuable centre of information on matters connected with lighting, and we shall follow its work with close attention and interest. We may add that, owing to the kind support of our Corresponding Members, we hope to be kept informed of the Committee's progress, and will keep our readers in touch with this important development.

Meantime we venture to think that the striking step thus taken by France might be followed shortly by action of a similar nature on the part of the Governments in other countries.

In addition to the work of the Conseil d'Hygiène de la Seine, we have mentioned, as instances of the growing interest of authorities in industrial lighting, the special references to the subject in the Reports of H.M. Inspector of Factories; in the recent Report of the Departmental Committee on Accidents; in Factories and Workshops; and the prominent place occupied by lighting questions in the deliberations of the Congrès International des Maladies Professionelles, held in Brussels last year.

We should like this country now to take more definite action on this matter, if only to show that the questions now being considered by Continental authorities are not being neglected here. The references made above to the work already done show emphatically that the authorities have this matter at heart, and the proposed Committee would merely be the logical outcome of their efforts; there seems to be excellent precedent for the step, and an influential Government Committee could naturally do better work than any individual, however gifted, is likely to do. In collecting information the Committee would no doubt bear in mind the data now being gathered by such bodies as the National Association for the Conservation of Vision in the United States; and we feel confident that the Illuminating Engineering Societies, both in America and in the United States would be only too glad to lend their aid.

The Coronation Illuminations.

Now that the bustle and excitement of the Coronation festivities are over we have taken the opportunity to publish a review of some of the chief features in the illuminations (see pp. 468-476). The photographs of typical installations accompanying the article suffice to show the methods of lighting used on this occasion; possibly had the restrictions imposed by the authorities been a little less severe, and somewhat more generous facilities for taking photographs and measurements of illumination been granted, fuller details might have been given, and a better record kept of the methods of illumination used.

Speaking generally, however, there were not many striking developments in decorative lighting to record; the present occasion was marked rather by the use of light on an unprecedented scale than by the introduction of any very new methods of application.

Nevertheless there were instances in which the judicious selection of colours, and the combination of lamps with coloured draperies, showed artistic skill, and there were also occasional cases of considerable ingenuity in the preparation of illuminated signs and devices.

There is also a tendency, which will probably develop as time goes on, to make use of illuminated surfaces and to rely less on the exhibition of the actual sources of light. The installation at White's Club was a case in

point, and the extensive use of coloured medallions of crowns, portraits of the King and Queen, thistles, shamrocks, &c., all of which were fringed in with incandescent lamps, was another illustration of the same thing. It was noticeable, too, that frosted lamps were more frequently used for this purpose than formerly—a desirable principle, since it becomes very difficult to distinguish designs of this kind when surrounded by a halo of clear bulbs.

At the same time it must of course be recognized that festive lighting of this kind is largely governed by popular taste. The demand for intense brilliancy is merely an involuntary expression of the old-established and traditional feeling that the lavish use of light is the most appropriate method of marking a joyous occasion. It should also be borne in mind that, after all, demonstrations of this kind are individual and purely voluntary efforts, and, within limits, any one is free to select the method of illumination he prefers. The case is on quite a different plane from the illumination of a school, library, or factory, where imperfect methods of lighting exercise, in the long run, a most prejudicial effect from the hygienic standpoint.

We may expect, however, that there will be in the future a growing demand for really novel and artistic methods of decorative lighting, and those who understand effects of this kind will find their services in demand. The clinging to the traditional methods is merely the result of the fact that little has yet been done to show that other and better things are possible. We hope, therefore, that this matter will receive the attention of members of the Illuminating Engineering Society.

There is one other aspect of public illuminations that deserves final mention, namely the possibility of co-operation. It must be confessed that the result of the present system of individual effort is chaos. Every householder is free to arrange his own scheme of decoration without regard for that of his neighbour; the result is that we have various colours and styles of lighting jumbled together in a most heterogeneous manner, and two displays which are individually excellent may kill each other. We cannot help thinking that much finer effects would often be secured if a single system could be adhered to throughout an entire street and the general effect planned out as a whole.

Courses of Lectures in Illuminating Engineering.

We have recently drawn attention to the need for instruction in Illuminating Engineering in this country, and it will be recalled that a trial course of this kind was organized last winter at the Westminster Technical Institute.

Since that time the governing bodies of several of the principal technical colleges in London have been considering this matter, and a series of lectures are to be delivered during the coming Autumn.

It need not be said that we appreciate very highly the enterprise of the governing bodies of these colleges in taking this matter up and in recognizing that the time is ripe for steps in this direction. We hope before long to be in a position to make a more definite announcement regarding these courses. We understand that the different illuminants, electricity, gas, oil, acetylene, &c., will be dealt with impartially, and that the measurement of light and illumination, the effects of light upon the eyes, shades and reflectors, and practical problems such as school, shop, and factory lighting will be included in the syllabus. The lectures will be delivered by experts who have made a special study of these various subjects, and should prove of considerable interest to many members of the Illuminating Engineering Society.

The lectures will be of a popular and interesting character, and will be arranged with a view to attracting interest in the subject rather than as

a course for experts. This seems to us exactly what is needed. At the present moment what is chiefly needed is to give opportunities to the public of understanding how many thoroughly practical and important problems there are which call for study. As a result of such lectures the idea of Illuminating Engineering will gradually become more familiar, and we may expect in a few years to see a post-graduate course eventually established in this country.

Restaurant Lighting.

The question of restaurant lighting (referred to on pp. 477–480 in this number) is by no means a simple problem. Good illumination is often a useful asset to the caterer, because it serves to attract attention. A reasonable standard of illumination is also essential in the interests of the routine work of the establishment. In badly lighted surroundings utensils are rarely kept as clean as they should be, things get out of place, and slovenly methods are very apt to become habitual. It may be added that not only sufficiency, but also proper colour of light, is desirable; the appearance of food, both in the kitchen and on the table, is often a guide as to the standard of the cookery and materials, and light of a peculiar colour is apt to be very misleading in this respect.

But apart from these general principles, which underly all restaurant lighting, there are certain aspects connected with the special variety of business done by the restaurant which must be borne in mind.

In some cases the intention is to provide for people who merely make a casual visit in order to get light refreshments, stay a short time, and then take their leave. A strong general illumination is here considered necessary in order that the manager may be able to take in the room at a glance and ensure that no customer in any quarter will be overlooked. The customer, on his part, usually prefers a bright, cheerful illumination; very probably he comes in alone and likes to look around him while taking his meal.

But there is another branch of business which is quite distinct, for example, providing for diners who really utilize the meal as an opportunity for meeting friends and carrying on conversation. Under these conditions there is not the same necessity for speed. Dining proceeds in a leisurely manner, and a bright general illumination is not always desired. Customers prefer a subdued local illumination of a "cosy" character, the tables being frequently set in little alcoves; this is conducive to a private talk, and promotes a feeling of restfulness and comfort. This method is very generally employed in restaurants of a high class, and lends itself to very artistic effects. Probably the impression derived through the eye is an essential part of the pleasure of such a meal.

In passing, it may also be pointed out that the quality of the lighting together with the furnishing, and the style of the decorations, &c., is one of the readiest means of conveying to the customer the class of the restaurant; if the surroundings and the scheme of illumination are of an artistic and elaborate nature, he is prepared to be charged a little extra.

It may be noted that in many cases both styles of lighting are provided simultaneously. For example, the central part of the room may be brightly illuminated and the "cosy" conditions of lighting aimed at only in the alcoves distributed round the room.

The interesting point to be observed is this; it is very essential that the lighting engineer should have a knowledge of the requirements and the variety of trade done by the restaurant which he is called upon to illuminate. In short, he must not only study the technical details of his profession, but must have a good knowledge of human nature.

LEON GASTER.

Review of Contents of this Issue.

THE article on the **Energy Losses in Electric Incandescent Lamps** by DR. E. P. HYDE, F. E. CADY, and A. G. WORTHING is concluded in this number (p. 445). The authors describe the way in which they eliminated errors when comparing the brightness of the filament tested with that of a calibrated lamp serving as a background. They then show how it is possible to analyze the various losses in a filament. Those due to conduction at the leading-in wires are shown to be quite appreciable, in the worst case amounting to 7 per cent on normal working; the losses in all cases increase greatly as the voltage is lowered below the normal. The principal element in determining the loss of energy in a particular type of lamp appears to be the length of filament between successive supporting points.

Following this is a note on the use of **Primary Batteries for Country House Lighting.** This has been suggested as a possibility by MR. W. R. COOPER owing to the introduction of a new type of bichromate cell, some particulars of which are given. It is suggested that although the cost of upkeep is considerable, the saving in initial expense and therefore in interest on capital, makes the total cost not very different from that of a battery of accumulators.

Some data with regard to **Searchlights for Illuminating the Exteriors of Buildings,** given by DR. LOUIS BELL in a recent lecture at the Johns Hopkins University, are summarized on p. 454. Reference is made to two difficulties commonly met with. One is the small reflecting power of the surfaces of buildings in a smoke-laden atmosphere, and the other is the necessity of avoiding very abnormal shadows, quite different from those cast by daylight. Useful formulæ are given for determining the illumination that will be delivered by a searchlight using a definite amount of power when the reflective coefficient of the mirror system is known.

An important announcement of the appointment of a **State Committee on the Hygienic Aspects of Illumination** by the Minister of the Interior in France is dealt with on p. 455. The main objects of the Committee are explained. Such questions as the cause of the prevalence of short sight and defects of vision, the amount of illumination requisite for various purposes, the best means of testing, determining, and measuring illumination in practice, &c., are to be discussed by this commission, and its representative character may be judged from the list of members which is printed in full, and which includes eminent oculists, gas and electrical engineers, inspectors of factories, &c.

On page 457 will be found some notes on **Light and Shade in Indirect Illumination,** in which some of the views put forward by recent writers on the subject are discussed, and some experiments undertaken by MR. J. ECK are described. The experiments were carried out in an art studio containing statues and casts of various kinds, the chief object being to determine how far the artificial illumination produced by inverted arc lamps differed from the daylight illumination in respect of light and shade effects. Photographs were taken of a statue, a sphere, and a disc, both by artificial and natural light, and in addition photometric measurements were made of the actual contrast between light and dark portions. These experiments were designed to show that although the actual surface brightness varied under the different conditions, the ratio of the bright and dark portions remained substantially the same in daylight or artificial light.

DR. C. R. BÖHM (p. 461) reviews the progress that has been made in the

Manufacture of Incandescent Gas Mantles since the appearance of his former article on 'Incandescent Gas Lighting.' He briefly describes a number of improvements that have taken place in the various processes of manufacture. Special stress is laid on the development in the burning off, shaping, and hardening stage. Here machines have largely replaced the manual work of female operatives, and the advantages gained, both in increased output for a given amount of labour and in the greatly improved conditions of the workers, are considerable.

Following this is a short account of the **Lighting of the South London Art Gallery**, contributed by AN ENGINEERING CORRESPONDENT. In the Ruskin Gallery, mainly used for pictures, gas lighting is installed, the general effect of the illumination being excellent. The lighting of a statue in this room, however, is not altogether above criticism.

Some space in this number is naturally devoted to **Notes on the Coronation Illuminations**. Some photographs, taken by artificial light, are presented showing the systems of illumination by gas and electricity. On the whole, it is suggested, although light was used on a very extensive scale, few very striking developments are to be recorded; the majority of the exhibitions consisted mainly in festoons of incandescent lamps, but there were a few instances in which effective use of illumination by concealed lights was effectively utilized, and attractive combinations of lamps and draperies was made.

The article also makes reference to acetylene installations, and concludes with an account of the illuminated shells used in the Naval Review.

On page 466 is a brief report of the **Annual Meeting of the Institution of Gas Engineers.** This contains a list of the papers and reports presented, special mention being made of the paper on **Public Lighting** by MR. S. B. LANGLANDS. In conclusion a quotation is given from the latter paper in which the author pays his testimony to the value of the work of the Illumina ting Engineering Society.

Restaurant Lighting is the subject of a short article on page 477, in which are emphasized the special features which must be borne in mind by the illuminating engineer in order to produce a successful scheme of lighting. It is pointed out that there are severa distinct types of installations required according to the class of customer being catered for. For example, a bright, attractive general illumination is most suitable for a room used by those who come in for a few minutes only to have a cup of tea; whereas the more leisured visitor who brings a friend to the restaurant and intends to stay and chat over the meal will probably prefer a more subdued light giving a "cosy" effect. The article concludes with an account of some recent installations at the Cabin restaurants.

The **Illumination of Caves and Grottos** is a special branch of illuminating engineering which is dealt with on page 481. The lighting of the Mammoth Caves at Kentucky by means of oil flares is mentioned, and particulars are given of the use of electric light and acetylene in two of the caves at Cheddar in Somerset. Very beautiful effects are obtained by the skilful placing of lamps so as to show off to the best advantage the wonderful stalactites and the colours of the translucent material. The writer points out that, without the skilful use of artificial light, the beauties of these caves would never be fully appreciated.

Several **Short Notes on Illuminating Engineering** will be found on p. 485, and these are followed by some **Reviews of Books.** The usual **Trade Notes** and **Review of the Technical Press** conclude the number.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A Study of the Energy Losses in Electric Incandescent Lamps.

By Edward P. Hyde, F. E. Cady, and A. G. Worthing.

(*Concluded from page 393.*)

The exact significance of the background current corresponding to a disappearance of the test filament against the background is of interest in passing. If there was no absorption of red light in the passage of the radiation from the filament of lamp A (Fig. 2) through the bulb of A, or through the lens system B, or through the bulb of lamp C, the intrinsic brightness of the enlarged image of filament A in the plane of filament C would be the same as the intrinsic brightness of the filament A itself. If these conditions held, then when the current of lamp A was adjusted so that the test filament C disappeared against the background image of filament A the two filaments would have exactly the same emission in red. If both filaments were of the same material, *e.g.*, tungsten, which is the material of the background lamp, and if the surfaces of the two filaments, were the same, the two filaments would be at the same temperature and hence of the same colour. Owing, however, to absorption of light in the passage of the radiation from filament A to its image in the plane of C, it is necessary to operate lamp A at a higher temperature than would otherwise be necessary, and so the colour of the light from A is much whiter than that from a tungsten test lamp C when at a disappearance as seen in the telescope.

It is not necessary, however, to introduce any of the properties of lamp A into the determination of the conduction losses of lamp C. Lamp A is used only as a comparison lamp, and is entirely eliminated by a substitution method. The applicability of this method rests on the fact, pointed out above, that the cooling effect for the lamp being studied is relatively small, and is confined to the parts of the filament quite close to the supports. Under these circumstances, if the test filament C is operated at two different voltages, the ratio of the total emission at the two voltages of a millimeter length of filament taken near the centre of the filament, *i.e.*, away from the supports, is the same, to within second order differences, as the ratio of the power supplied to the lamp as a whole at the two voltages. This relation furnishes a method of interpreting the observed values of background current in terms of watts radiated by different portions of the test filament. Thus, after having explored the entire filament of lamp C, by moving it up and down, and determining the background current for disappearances at each of a number of points along the filament, some part of the filament away from a support is brought again into the field of the telescope so that it is seen against the background image. The voltage of the test lamp, which was maintained constant during the previous test, is now varied, and the background current is adjusted so that there is a disappearance, *i.e.*, so that the test filament C and the image of A are at the same apparent brightness. By varying the voltage of the test lamp C over a

large range, making background-current determinations at frequent intervals and measuring the watts of the test lamp at each voltage, a calibration curve is obtained between the current in the background and the watts supplied to the test lamp, which latter may be taken as proportional to the watts radiated by the element of filament of the test lamp under investigation. Such a calibration curve for the tungsten lamp to which Fig. 3, curve "A," applies is shown in Fig. 4, curve "A." If now for the background current readings in Fig. 3, curve "A," the corresponding watts of the test lamp are plotted, the resulting curve (curve "B," Fig. 3), plotted in terms of an arbitrary unit, will give the relative energy radiated by every element of filament of the test lamp C at the fixed normal voltage of the lamp. The integral of this curve will give the total power radiated by the filament, expressed in the same arbitrary unit.

Now, since the energy supplied to an element of filament near the centre, *i.e.*, away from the supports, is all radiated, there being no conduction loss, the curve of power supply for this portion will coincide with that of power radiated, if plotted to the same scale. As the leading-in and supporting wires are approached, however, the two curves will diverge. If the resistance of every element of filament were the same, the curve of energy supply would be a straight line parallel to the axis of abscissae. On account of the cooling at the contact points, however, the resistance of unit lengths of filament near the contact points will differ from that of a unit length in the central region of the filament, and hence the power supplied to these elements near the contacts will be different from that supplied to the central portion, being directly proportional to the resistance.

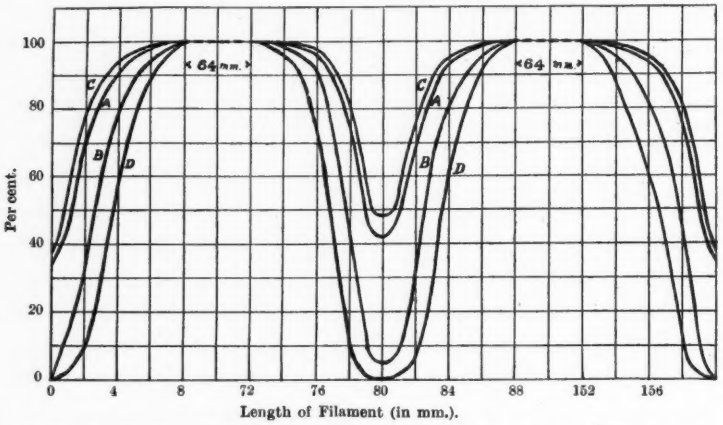


FIG. 3.—Sample Curves, showing conduction losses for a 60 watt, 110 volt Mazda lamp.

Curve A = Relative current values of background lamp.
Curve B = Relative output distribution.
Curve C = Relative input distribution.
Curve D = Relative distribution of light flux.

The resistance of every element of filament can be determined in a way quite similar to that employed in the determination of the radiation from each element. Fig. 4, curve "B," gives the resistance of the entire filament of the tungsten test lamp (expressed in an arbitrary unit) plotted against the background current values which give a disappearance for a central portion of the filament at varying voltages. The ratio of the resistances of the whole lamp at two voltages may be con-

sidered to within second order differences as equal to the corresponding ratio of the resistances of a unit length of filament near the centre. Hence from curve "B," Fig. 4, may be read the resistance of any element of filament corresponding to a background current taken from curve "A," Fig. 3. If the watts supplied to an element of filament near the centre be taken as unity, then the power supplied to any element of filament near the contacts will be that fraction of the power supplied to a central element which the resistance of the end element is of the resistance of the central element. The power supplied to every element of the tungsten filament which has been taken as an example is given in Fig. 3, curve "C." The integral of this curve gives the total power supplied to the filament, and the ratio of the integral of curve "B" (the total power radiated) to the integral of curve "C" (the total power supplied), gives the proportion of the supplied power which is radiated. The difference between this ratio and unity gives the percentage of power lost by thermal conduction. In the case of the tungsten filament in the illustration it amounts to 4 per cent.

From an inspection of Fig. 3 it is seen that curve "B" giving the radiated power is extrapolated to zero at the contact points, whereas curve "C" is given finite values at these points. Unquestionably the filament has a temperature above that of the surrounding medium even at the contacts, and so curve "B" should have finite values at these points; but in order that the maximum loss might be determined, it seemed advisable, in the absence of specific knowledge of the true values at these points, to assume the worst case by extrapolating to zero.

Having determined the power supplied and the power radiated for every element of filament, it only remains to measure the luminous flux for every element of filament, and thus to determine the loss in efficiency due to the losses of energy by thermal conduction. The method pursued in determining the luminous flux of each element of filament is entirely analogous to that used in getting the power supplied and the power radiated by each element. Thus Fig. 4, curve "C," gives the

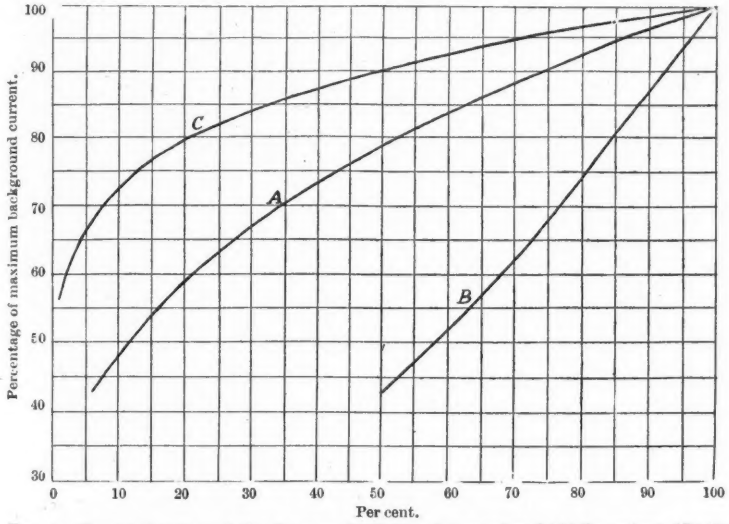


FIG. 4.—Curves showing relation between background current and (A) the output, (B) the resistance, (C) the luminous flux of a 110 volt, 60 watt Mazda lamp.

relation between the luminous flux of the whole lamp and the background current corresponding to a central portion of the test filament at different voltages. From this curve, in conjunction with curve "A," Fig. 3, it is a simple matter to compute the curve of luminous flux, as shown in curve "D," Fig. 3, plotted in terms of an arbitrary unit. The integral of this curve gives the total luminous flux of the whole filament, and the ratio of this integral (the total luminous flux) to the integral of curve "C" (the total power supplied) gives the efficiency in terms of the efficiency at the centre of the filament taken as unity. The difference between this ratio and unity gives, therefore, the percentage loss in efficiency due to the losses by thermal conduction. In the case of the tungsten filament which is taken as an example this loss amounts to 7 per cent.

III. Experimental Results.

The method described fully in the preceding section may be summarized briefly. (1) The current values of the background lamp corresponding to a disappearance of the various parts of the test filament at constant voltage are determined. Then for some central portion of the test filament the following three relations are determined by varying the voltage of the test lamp and recording the corresponding background current; (2) background current *versus* foreground watts; (3) background current *versus* foreground resistance; (4) background current *versus* foreground luminous flux. By combining (2), (3), and (4) with (1), it is possible to obtain the power supplied, the power radiated, and the luminous flux for every element of length of the test filament.

In actually carrying out the investigation, the method given above was not followed rigorously. Thus, the background lamp was employed only in determining relations (1) and (2). For relations (3) and (4) were substituted the following, which in the light of relation (2) give all the necessary data: (3′) foreground watts *versus* foreground resistance; (4′) foreground watts *versus* foreground luminous flux.

In practice the method consisted in first determining relation (2), which may be considered a calibration of the background filament. Then relation (1) was determined, but the results were not reduced to a curve. The calibration of the filament, relation (2), was then repeated, and the mean of the two calibrations plotted in the form of a curve. From this curve the watts value of every observed background current value in relation (1), was read-off, and the results plotted in the form of a curve, in which distances along the filament were taken as abscissae, and watts radiated (in an arbitrary unit) as ordinates.

In getting relation (2) the test lamp was set at various voltages, and the background current for a disappearance was obtained; at the same time current readings of the test lamp were taken. From the latter the watts and resistance at each voltage were computed. In this way relation (3′) was obtained simultaneously with relation (2). To get relation (4′) the lamp was set up again, since the experimental arrangement did not permit candle-power determinations to be made at the same time as the other measurements.

As a background lamp a large filament tungsten lamp was used. The filament was approximately 0·4 mm. in diameter, and was of an inverted U-shape, mounted in a large bulb. Several different lamps were used; in some cases the bulb was spherical, in others of the more usual pear-shaped form. In each case the filament was so mounted that the end of the loop came near the centre of the bulb. This portion of the filament was in general chosen as the background for the measurements.

The investigation was carried out with the following four lamps, each at two different voltages: 16 c.-p., 115 volt, 3·1 w.p.c. carbon lamp; 40 watt, 110 volt tantalum lamp; 25 watt, 115 volt mazda lamp; and 60 watt, 110 volt mazda lamp. The losses were determined at voltages corresponding to approximately normal operation, and at very low voltages so chosen that all the lamps were at about the same colour as the carbon lamp

at 75 volts. Only one lamp of each type was used, as the observations and computations are quite laborious, and as it is felt that there is no reason why the losses should differ greatly from lamp to lamp of the same type and at the same efficiency.

The carbon lamp was of the anchored oval type, thus having two leading-in wires, and one anchor at the centre of the oval. The tantalum lamp was of the continuous filament variety, with two leading-in wires and twenty-one loop supports. The 25-watt mazda lamp, and similarly the 60-watt mazda lamp, had four filaments, each of which was welded at the base contacts and supported at the other end by a loop support. There were thus two leading-in wires, six other welded supports, and four loop supports. In the case of the carbon lamp, the filament was investigated in the region of each leading-in wire and of the one anchor. The effect of the two leading-in wires, and then of the twenty-one loop supports, was studied in the tantalum lamp. In the 25-watt mazda lamp the losses at the two leading-in wires, at three of the six other welded contacts, and at two of the four loop-contacts were determined. In the 60-watt mazda lamp approximately the same number of contacts were studied.

The losses at the loop-contacts were the most difficult of measurement because of their changing nature. By taking a relatively large number, however, a fairly accurate result was obtained.

The results of the investigation are given in Figs. 5 and 6, and in Table 1. In describing the general principle involved in the method, typical curves for a 60-watt mazda lamp were given in Fig. 3, curves "A," "B," "C," and "D." In giving the final results it has seemed better to plot the average curves for each lamp. Thus in Fig. 5, curve "A," the abscissæ are the average distances from the contact points, and the ordinates are the average values of power supplied to the filaments at the corresponding distances from the contact points. The ordinates are expressed in terms of an arbitrary unit, so chosen that the value of the maximum power supplied per unit length of filament is unity. Curve "B" gives the average power radiated

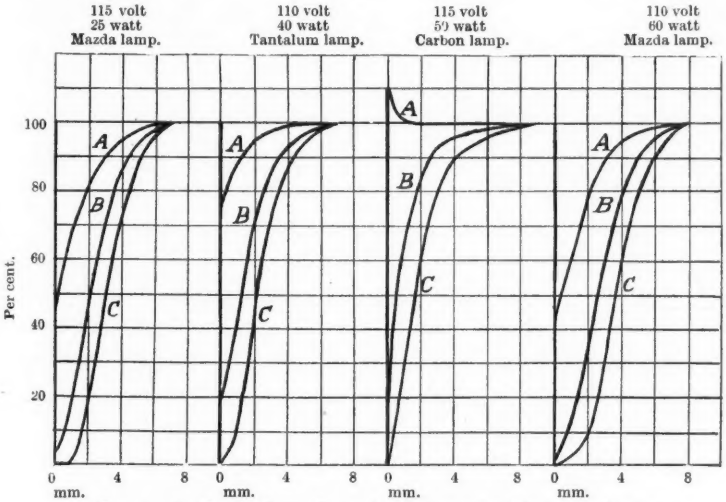


FIG. 5.—Conduction losses for various lamps operated at normal voltage.
Curves A = Relative input distribution.
Curves B = Relative output distribution.
Curves C = Relative distribution of luminous flux.

at various distances from the contact point; and curve "C" shows the average luminous flux per millimeter length of filament. The area between curves "A" and "B," divided by the area enclosed under curve "A," *properly extended*, gives the percentage loss in power due to thermal conduction at the contacts. The area between curves "A" and "C" divided by the area enclosed under curve "A," *properly extended*, gives the percentage difference between the actual efficiency of the lamp and the efficiency of the most efficient part of its filament, *i.e.*, the part of the filament away from the cooling effect of the contacts. The reason why the average efficiency of the lamp is lower than that of its most efficient part is to be found in the fact that the efficiency of those parts of the filament near the contact points is quite low. The amounts of the losses in power and the losses in efficiency for the various lamps are given in the respective figures, and are collected in Table 1.

TABLE 1.

Summary of energy and luminous efficiency losses in various types of lamps due to the conduction of heat away from the filament at the leading-in and anchoring wires.

Lamp.	Voltage	Watts M.H.C.	Energy loss per cent.	Efficiency loss per cent.	Distance between successive contacts.
Tantalum	110	2	7	13	33 mm.
40-watt	50	11	14	27	
Carbon	115	3·1	2	4	106 mm.
50 watt	75	18	3	5	
Mazda	115	1·25	4	7	69 mm.
25-watt	45	12	9	15	
Mazda	110	1·25	4	7	80 mm.
60-watt	45	11	8	16	

In the first column of Table 1 are given the various lamps used; in the second and third columns the voltages and the watts per mean horizontal candle at normal operation and at reduced voltages; in the fourth and fifth columns are given the percentage losses in watts and in efficiency at normal operation and at reduced voltages; and in the sixth column are given the lengths of filament between two successive points of support for the various lamps. It will be observed first that the power losses (fourth column) in the case of ordinary lamps at normal operation are relatively small, amounting only to about 7 per cent even for the tantalum lamp, which shows the largest loss. As the voltage is decreased, the loss becomes relatively larger for every lamp; but even at the very low voltages used, and for the worst case of 14 per cent loss in the tantalum lamp operating at 11 watts per mean horizontal candle, the power losses are still considerably less than the values given by Leimbach for normal operation.

The efficiency losses (fifth column) are considerably larger than the power losses, owing to the fact that the luminous flux decreases several times as fast as the power, when the temperature is lowered. At normal operation the efficiency losses owing to the cooling effect of the supports range from 4 per cent for the carbon lamp to 13 per cent for the tantalum lamp. At the reduced voltages at which measurements were made, the efficiency losses range from 5 per cent for the carbon to 27 per cent for the tantalum lamp. It is perhaps well to explain the exact significance of the efficiency loss. By this is meant the difference between the average efficiency of the filament as a whole and the efficiency of its hottest, central portion. If there was no conduction of heat at the supports these two quantities would be the same; but, owing to the reduced efficiency of the parts of the filament near the supports, the central portion must be operated at a higher efficiency than would otherwise be necessary to secure a given average efficiency of the filament as a whole.

It should be emphasized that the results given above were obtained on single specimens of each type of lamp, and that the types of lamps were the standard types in commercial usage. Although it is thought probable that the percentage losses for other specimens of similar types would exhibit no marked differences in the magnitude of the losses, it would seem quite certain that other types of lamps would in general show different losses.

From a consideration of the curves given in Fig. 5, and the numerical results collected in Table 1, it would

seem that the relatively large loss for the tantalum lamp is to be ascribed to the large number of supports, and the correspondingly short lengths of filament between successive supports. Although this is unquestionably the case, one is not justified in concluding *a priori* that the life of the tantalum lamp would be improved by reducing the number of supports and increasing the free length of filament. Other considerations of a practical nature enter, and these must be given due weight in determining the most efficient construction. It is a matter of interest, however, to know specifically the magnitude of the losses in various types of lamps due to the conduction away of heat at the leading-in and anchoring wires.

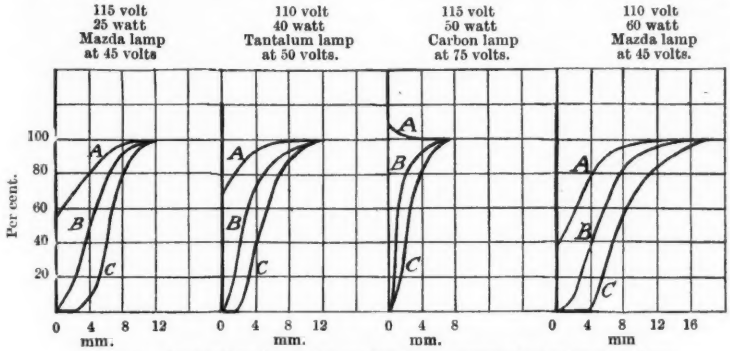


FIG. 6.—Conduction losses for various lamps operated at reduced voltage.
Curves A = Relative input distribution.
Curves B = Relative output distribution.
Curves C = Relative distribution of luminous flux.

Although complete measurements of the losses were made only at two voltages for each lamp, viz., that of normal operation, and that corresponding to a colour match with the carbon lamp at 75 volts, a series of measurements at intermediate voltages was made which makes possible a fairly accurate interpolation for any voltage intermediate between the two voltages for which values are given. This series of measurements consisted in determining the loss at some one contact (the contact at one of the leading-in wires was chosen in every case) corresponding to a number of intermediate voltages, and assuming that the total loss at any voltage is proportional to the loss at this one contact for all voltages intermediate between the two extremes. The interpolation curve for each lamp is given in Fig. 7, in which ordinates are voltages expressed in percentage of the voltage for normal operation, and abscissae are percentage energy and efficiency losses respectively.

From Fig. 7 it is possible to compute the approximate energy and efficiency loss at any voltage, and thus to determine the corrections which must be applied to the measured lumens per watt at any voltage in order to obtain the true lumens per watt at which the central portion of the filament is operating. As the efficiency losses, particularly for some types of lamps, are fairly large when the lamps are operating on low voltage, the numerical results of selectivity as given in previous papers by one of the present authors *et al.* will need some revision. A full discussion of this point will be reserved for a future paper. Suffice it to say at present that the direction of the correction is such as to indicate a larger difference between carbon and metals in respect of the selectivity of their radiation than that given in the previous papers on this subject. Moreover, it is possible that the relative arrangement of the metals, as, for example, between tantalum and tungsten, may be altered somewh

though this is not yet determined. The authors hope to repeat the original experiments, at least in part, in order to secure accurate results, correcting for the losses due to thermal conduction and for such other losses as may affect the numerical results.

IV. Summary.

The results of the investigation of certain of the losses that occur in ordinary incandescent electric lamps may be summarized as follows for those types of lamps which were studied :—

1. Of the energy supplied to the lamp practically all is transformed into heat in the filament itself, only a small fraction of 1 per cent being dissipated as C^2R loss in the leading-in and connecting wires.

2. Of the energy transformed into heat in the filament, that which is lost through the convection and conduction of heat by the enclosed gas is in all normal lamps entirely negligible.

3. The energy losses due to thermal conduction at the leading-in and supporting wires are quite appreciable for all types of lamps and for all voltages studied. The losses are larger for certain types of lamps, such as the tantalum lamp, than for others, such as the carbon ; and for all types the losses increase greatly as the voltage is lowered below that corresponding to normal operation. The energy losses at normal operation are relatively small, amounting, in the worst case studied, to only 7 per cent.

4. The efficiency losses due to thermal conduction are somewhat larger than the corresponding energy losses, and even at normal operation are as large, in the case of the tantalum lamp, as 13 per cent. Moreover, the efficiency losses increase rapidly as the voltage is reduced.

5. The principal element in determining the magnitude of the losses is the free length of filament between successive contacts.

6. The efficiency losses found are of such a character that there is no need

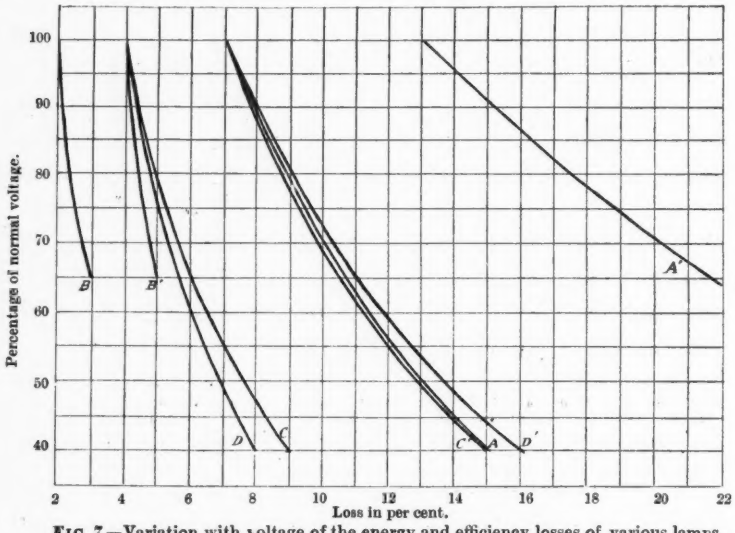


Fig. 7.—Variation with voltage of the energy and efficiency losses of various lamps.
Curves A, B, C, D, are of energy losses.
Curves A′, B′, C′, D′ are of efficiency losses.

A and A′	= 40 watt	Tantalum, 2 w.p.c.,	at 110	volts.
B „	B′ = 50 „	Carbon, 3·1	„ „ 115	„
C „	C′ = 25 „	Mazda, 1·25	„ „ 115	„
D „	D′ = 60 „	Mazda, 1·25	„ „ 110	„

for any modification in the general conclusions as to the selectivity of radiating metals which were arrived at in a previous investigation on the assumption that all the energy supplied to a lamp is transformed into radiant energy. The numerical results given in previous papers need some revision, and it is possible that the order of arrangement of the metals as to selectivity may undergo some change. The general conclusions, however, remain unaltered.

7. No measurements were made of the total energy losses which result from the absorption by the glass bulb and whatever deposit there might be on the inside of the bulb. The absorption by the bulb of the luminous flux from the filament is approximately 2 or 3 per cent in new lamps, but may be very large in lamps which have burned a great many hours. No measurements were made of the losses either in total energy or in luminous flux due to the base of the lamp.

Primary Batteries for Country House Lighting.

MOST people would be surprised at the idea of using primary batteries to supply a current for private house lighting nowadays; yet this suggestion has been made by Mr. W. R. Cooper in a recent communication appearing in the *Proceedings* of the Institution of Electrical Engineers, dealing with a remarkable new form of cell termed the "Benkö."

For lighting one, of course, needs a steady P.D. and a cell capable of furnishing a continuously and reasonably high current. The ordinary types of primary batteries do not comply with these requirements, largely because of the polarization effect which sets in immediately any appreciable current is taken. In the Benkö bichromate cell this appears to be avoided by enclosing the electrolyte in a porous carbon cylinder and arranging for a new supply of liquid to flow steadily through the cell while the used up material drains away, the rate of flow being adjusted according to the demands on the cell. By this means quite small cells capable of furnishing a considerable current are secured—conditions, in fact, closely resembling those existing in the accumulator. Remarkably constant P.D. and current discharge curves are obtained when the cell is connected to a constant resistance. Favourable results are also said to have been experienced with a battery of 18 Benkö cells in parallel with 12 accumulators.

In considering the lighting of a small country residence the author takes a house requiring fifty 10 candle-power metal lamps. The installation of a battery of accumulators, generator, &c., for such a house would cost about £200. The cost of generating energy would probably be about 6*d*. a unit, but if allowance is made for interest on the high initial expense this is raised to about 1*s*. 10*d*. per unit.

If, on the other hand, a Benkö battery were installed, the estimated initial cost would only be £20, but the cost of supplying the battery with zinc, sodium bichromate, and sulphuric acid would amount to about 2*s*. a unit—not very different from that in the first case.

In many cases, however, the cost, within limits, is of small import, and it is suggested that such a battery might be very convenient in several respects. For example, it requires no special storage house, and could be installed in the basement of the house, thus avoiding the high initial expense of a main cable. When in working it is said to demand no attention beyond turning on and off the flow of electrolyte at the commencement and end of the evening. Other cases in which, it is suggested, the cell might prove useful are the lighting of yachts having no generating plant, and submarines, and for miners' lamps.

Note on the Use of Search-Lights for Illuminating the Exteriors of Buildings.

With the Coronation decorations fresh in our mind it is of interest to notice some remarks by Dr. Louis Bell in his recent lecture on 'The Principles and Design of Exterior Illumination,' delivered at the Johns Hopkins University.

In the United States considerable attention has recently been paid to the method of illuminating the outsides of buildings by searchlights so as to display the architectural features. The system is comparatively new, and festive decorations have hitherto almost invariably taken the form of "outline lighting" with glow lamps. The problem presents a number of difficulties, and no little skill is needed to obtain a really successful result.

One of the main difficulties is that in cities with a smoke-laden atmosphere the surfaces of buildings have commonly but a small reflecting power, so that an immense amount of light is required to make much impression on a large façade. A second point is that we are accustomed to seeing the architectural features by daylight, *i.e.*, chiefly by strong light from above. Hence if the shadows are cast in some abnormal direction the effect is not satisfactory. It is necessary to strike a mean between an entirely vertical illumination, which does not show enough shadow, and a very oblique "grazing illumination," which throws into relief unusual shadows, and may produce effects analogous to the exaggeration of brush marks by very oblique lighting of pictures.

Some data given regarding calculations of the illumination from searchlights are also useful. Many people who understand how to deal with a point-source, which obeys the inverse square-law, are quite at a loss when sources backed by reflectors and yielding almost a parallel beam of light have to be used.

While it is difficult in such cases to assign any proper value to the candle-power, the total luminous flux is a quite definite quantity, and this should be ascertained and employed in calculating the resultant illumination.

The illumination in lux delivered by a searchlight, Dr. Bell remarks, is

$$L = \frac{4\pi e i \eta}{\pi r^2} = \frac{4 e i \eta}{r^2}$$

where e is the voltage of the arc, i the current, and η the "specific-efficiency" in mean spherical candle-power per watt multiplied by the net reflective coefficient of the mirror system, and r the radius of the beam of light.

Thus assuming $\eta = 1$
$e = 80$ v.
$i = 50$ amps.
$r = 10$ m.

We have $L = \frac{4 \times 80 \times 50 \times 1}{100} = 160$ lux.

In the same way we can readily solve the converse problem of ascertaining what the power given to the arc must be in order to produce a given illumination.

It may be added that although the illumination will naturally vary at different distances from the arc (unless the beam is exactly parallel), the total flux should remain the same. This, of course, leaves out of account the absorption of the atmosphere, which may be regarded as negligible in clear weather, but under misty and foggy conditions is very far from being so.

A State Committee on the Hygienic Aspects of Illumination.

THE last volume of *The Illuminating Engineer* contained many references to incidents which illustrated the trend of opinion in favour of greater care in the supervision of industrial illumination. The lighting of factories and workshops received prominent notice at the Second Congrès Internationale des Maladies Professionnelles, held in Brussels last year, in which the Illuminating Engineering Society took part. It was pointed out on that occasion how influential the deliberations of such a Congress must be, attended as it was by distinguished authorities from many parts of the world and Government representatives of the chief civilized nations. The official report that has just been issued on accidents in factories and workshops, and which was commented upon in our last number (p. 401), was yet another indication of the progress of events.

A most important announcement has been made in *L'Officiel* for June 16th; this may doubtless be ascribed to the influence of the Congress in Brussels, and establishes a most important precedent.

The announcement in question is as follows :—

At the instigation of the French Minister of the Interior a Technical Committee has been appointed to deal with natural and artificial illumination, and having for its main objects—

1. To study, from the standpoint of general health and its effects upon vision, the various methods of artificial lighting now in use.

2. To determine the composition and quality from a hygienic standpoint of the different combustible illuminants, and to examine the effect of prejudicial gases and the amount of heat developed thereby.

3. To fix a certain minimum amount of artificial illumination favourable to the normal requirements of vision.

4. To study the most practical methods of measuring illumination.

5. To formulate recommendations governing the best means of applying customary methods of lighting to the chief varieties of industrial operations.

6. To present to the Ministry a report on the subject of short sight and impairments of vision and on the best methods of guarding against the causes of myopia.

This Committee is stated to be composed as follows :—

M. Gariel, Vice-Président du Conseil Supérieur d'Hygiène Publique de France, Ingénieur en Chef des Ponts et Chaussées, Membre de l'Académie de Médecine, Professeur de Physique à la Faculté de Médecine (*Président*).

Dr. A. Broca, Professeur Agrégé de Physique à la Faculté de Médecine.

M. Le Docteur Chevallereau, Médecin en Chef des Quinze-Vingts.

M. Le Docteur Cosse, Oculiste en Chef des Hôpitaux de Tours, Secrétaire Général du Syndicat des Oculistes Français.

M. Delage, Chef de Laboratoire de la Société Française d'Incandescence par le Gaz.

M. Lamiraud, Inspecteur de l'Académie de Paris.

M. Le Docteur Morax, Médecin Ophthalmologiste des Hôpitaux de Paris.

M. Le Docteur Motais, Professeur de Clinique Ophthalmologique, Membre Correspondant de l'Académie de Médecine, Président du Syndicat General des Oculistes Français.

M. Seguin, Inspecteur des Arts et Manufactures, Inspecteur Departemental du Travail.

M. De Tavernier, Ingénieur en Chef des Ponts et Chaussées, Directeur de la Compagnie Électrique du Secteur de la Rive Gauche.

This Committee is to present a summary of its work to the Ministry

of the Interior every three months, and at the end of the year to present a final report embodying its conclusions.

The carrying out of this project will be the charge of the Directeur de l'Assistance et de l'Hygiène Publiques.

The Committee is of a most representative character. It includes among its members medical men in practice, professors of physics and ophthalmology, representatives of gas and electric lighting, inspectors of factories and workshops, &c., and should, therefore, act as a most valuable centre for impartial information of hygienic aspects of lighting. The progress of the work of this Committee will be watched with great interest by all in this country concerned with illuminating engineering.

For What Colour of Light is the Luminous Efficiency Highest?

THIS is a question of great interest. For most practical purposes we desire light that is at least approximately "white" in colour, and are willing to make a certain sacrifice in efficiency to secure this. But yet it is known that the sensitiveness of the eye to the central part of the spectrum is far higher than to the extreme red and violet. If, therefore, we could contrive to generate only this particular kind of highly efficient light this would often be a great advantage.

It is of consequence therefore to know exactly where in the spectrum is the highest luminous efficiency situated. This has long been recognized to depend upon the intensity of illumination, for with a very weak light the eye appears to be in quite a different physiological condition from that prevailing when the light is strong. It is necessary, therefore, to state the maximum in both cases. This has just been done by P. G. Nutting* who, by a correction of his former values, attains what he regards as the most reliable figures so far secured. According to these the maximum sensitiveness of the eye for strong illuminations should be at 0·544 μ, and at weak illuminations near 0·503 μ.

H. E. Ives also states that for light of wavelength 0·544 μ a luminous efficiency of as much as 65 c.p. per watt should be possible while for ideal white light, with energy confined to the visible spectrum 26 c.p. per watt should theoretically be obtained.

* 'Bull. Bureau of Standards,' May 15.

Glasses for Absorbing Ultra-Violet Light.

A VERY complete account of researches on different glasses of this kind has just been published by Dr. Louis Bell in the *Proceedings* of the American Academy of Arts and Sciences (vol. xlvi., No. 24, April, 1911).

He shows that the extreme ultra-violet portion of the spectrum can be effectively absorbed by a number of different kinds of amber and yellowish-green glass. It is to be noted, however, that such protective glasses do not obscure the *brilliancy* of the arc sufficiently for close range work, and special dense varieties and combinations are therefore necessary in addition. The paper contains some spectro-photographs showing the action of glasses of this description, and is also valuable for the number of references to work by Zschimmer, Schanz and Stockhausen, Hallauer, Voege, and others on the subject.

Light and Shade in Indirect Illumination.

By An Engineering Correspondent.

During the last few years there has been much discussion, especially in the United States, regarding the ideal conditions of artificial lighting for different classes of interiors. Leaving out of account the comparative economy of different systems, the question has been raised when and where it is desirable to flood the entire floor area with light, and to aim at a perfectly even illumination? Also, how far ought one to endeavour to imitate daylight conditions and its characteristic qualities as regards light and shade?

It has usually been assumed, not unnaturally, that we ought to imitate daylight, on the ground that the eye has been gradually developed to utilize the light of the sky and sun. Broadly speaking one must admit that any very radical departure from natural light would probably be unwise. On the other hand it must be remembered that daylight conditions, at different times of the day and under various climatic conditions, vary enormously; illumination from the direct sunlight is a very different thing from that obtained from the dull and clouded sky. Daylight conditions are not always ideal, and the intense glare of sunlight and the peculiar conditions in high altitudes may occasionally be highly prejudicial to eyesight. Let us therefore, in imitating daylight, make sure which are the conditions it is desirable to reproduce.

As a matter of fact, it is clear that the earlier impressions of daylight were somewhat mistaken. For example, many writers habitually spoke of it as perfectly uniform and shadowless, whereas in the average interior it is very far from being either. In the recent discussion of the Illuminating Engineering Society, figures presented by L. Gaster and J. S. Dow showed that in many school-rooms the variation in daylight illumination from one side of the room is enormous—often far greater than would ever be permitted in a respectably designed artificial scheme of illumination. On the other hand, the actual illumination is frequently very much higher, even in the worst lighted parts of the room, than it would be by artificial light. Consequently this extreme variation is not realized, and may not occasion inconvenience. It is only when daylight begins to fail that the results of this want of uniformity become apparent in the case of the more remote desks.

Since daylight (especially when received only from side windows), is in general far from uniform, it need hardly be said that it is also far from shadowless; indeed, it would not be convenient for many industrial processes if it were. While, therefore, the impression that light for industrial purposes should usually be uniformly distributed seems well grounded, the supposition that it ought also to be perfectly shadowless is not. There may be cases in which practically shadowless illumination is desirable, but there are not many.

Mr. Haydn T. Harrison* has recently advocated the use of two distinct systems of nomenclature intended to apply respectively to direct lighting, which gives powerful shadows, and to light received from very extensive illuminated surfaces, which, of course, would yield shadows of a less pronounced character. He suggests that indirect illumination is "shadowless," and that it would, for example, cause a white sphere to appear to the eye the same as a white disc of similar diameter and would not be satisfactory for the great majority of practical operations.

* *Electrician*, May 26th.

It may, however, be doubted whether there exists any system of artificial illumination which can be described as shadowless, and it is certainly very difficult to divide methods of lighting into two sharp classes, those which give shadows and those which do not. On the contrary, we have imperceptible gradations from the very sharp effects produced by the naked arc light, glow-lamp, or mantle to the soft shadow given by indirect systems. In the recently issued Report of the Departmental Committee on Accidents in Factories, several witnesses alluded to the misleading dead-black shadows

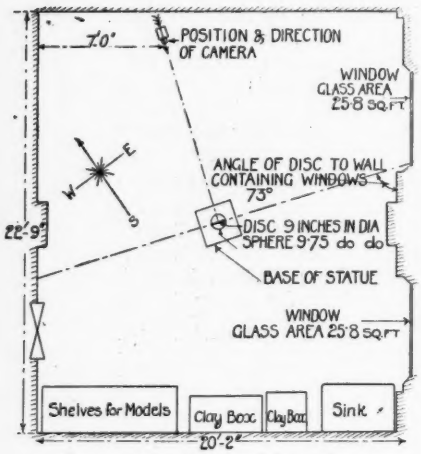


FIG. 1.—Plan of Room in which Experiments were made.

cast by improperly arranged naked arc lights; this suggests that unduly sharp shadows may be unsatisfactory, just as complete absence of light and shade would be.

In the same way shadows thrown in the wrong direction, and multiple shadows thrown by systems of lighting consisting of a number of distinct units, are also sometimes provoking. To sum up, therefore, it would seem that the chief points to be observed are two in number, *firstly*, to secure that lamps are so placed that the direction of shadows is not inconvenient; *secondly*, to arrange for the effective screening of sources of light, both with a view to avoiding glare and to prevent shadows which are inconveniently harsh. It still remains to be determined, however, exactly what kind of shadow is needed for different purposes. One would imagine that moderately soft conditions would be required in cases in which architectural and artistic effect must be studied. But when very fine and intricate detail is to be studied somewhat more sharply defined shadow might be desirable.

An interesting contribution by Mr. Justus Eck,* dealing with light and shade in indirect lighting, followed the article by Mr. Harrison in *The Electrician*. By the courtesy of the author several illustrations are here reproduced showing the nature of the experiments carried out with the object of demonstrating that indirect illumination is by no means "shadowless." In view of the frequent use of such methods of lighting in rooms devoted to sketching from the cast, modelling, &c. (*e.g.*, at the Art School of the Westminster Tech. Institute), the question is one that deserves attention.

Curiously enough the same point has just been dealt with in a paper by J. R. Cravath before the Illuminating Engineering Society in the United States.† After describing tests on a small room illuminated by a number of different systems he concludes :—

"In considering the objectionableness of shadows, it must be remembered that it is not altogether a question of the absolute amount of illumination obtained in the shadow, but rather of the contrast between the illumination in the shadow and the surrounding illumination. It is for this reason that the shadows with indirect illumination appear so much less than with direct illumination. Nevertheless the actual amount of shadow with indirect illumination as shown by these tests will doubtless be a surprise to many who have considered indirect illumination of this kind almost shadowless. While the shadows are far less than with direct illumination it is far from being shadowless."

* *Electrician*, June 23.

† *Trans.* Amer. Illum. Eng. Soc., April, 1911.

In the article referred to it is pointed out by Mr. Eck that it is difficult to arrive at conditions when *no* shadow at all is produced, even when the lamps are symmetrically placed with regard to the room and the walls, ceiling, and floor are dead white. It is only when we arrive at the conditions that prevail inside an Ulbricht globe—when a very small sphere is placed in a whitened room of approximately spherical form—that such a condition of things becomes possible. But in practice the ceiling is almost invariably vastly brighter than the walls and surroundings and a very marked shadow exists.

There are two methods of attacking this problem, both of which were used by Mr. Eck. One may take photographs of the interior and objects inside it, so as to portray the exact shadow conditions exactly as they occur when the room is artificially lighted. And one can profitably supplement these photographs by actual measurements of the surface-brightness of these objects so as to demonstrate what the actual contrast in light and shade really is. This last method should yield specially valuable results. The artistic appearance of statuary is mainly dependent on the conditions of light and shade. Yet we have few if any data available informing us how the shadow differs by day and artificial light respectively and what are the conditions which are ideal from the artistic standpoint.

Mr. Eck's experiments were carried out in a room devoted to artistic and modelling work and containing statues and casts. The room was lighted by a single centrally suspended inverted arc-lamp. The first experiment consisted in the mapping out of the surface-brightness of the walls and ceiling by day and artificial light. A series of measurements with the Holophane Lumeter about 10.30 A.M. in the daytime showed that the surface-brightness of the walls varied from about 2·6–5·6 foot-candles, and that of the ceiling from 3·6–7·8. By the arc-light the surface-

FIG. 2.—Showing Arrangement of Camera by which the View shown in Fig. 3 was taken, and its position with respect to: (*a*) the Windows (*b*) the Light Source, and (*c*) the Disc, Sphere, and Statue photographed.

brightness of the lower part of the walls varied from 0·63 to 1·4, that of the light dado from 3·5 to 5·2, and that of the ceiling from 30 to 54 foot-candles. It would seem, therefore, that, judging from the surroundings, the variation in light and shade by the indirect lighting was not less, but considerably greater than by daylight.

The next experiment dealt in a very interesting manner with the point

FIG. 3.—Showing Light and Shade and Conditions of Shadow on Disc, Sphere, and Statue, immediately below Inverted Arclamp.

raised in Mr. Harrison's article, namely, the appearance of a disc and sphere of the same diameter and material. In order to test this point a disc and sphere were hung up, one above the other, near the centre of the room (where the conditions are probably most favourable to absence of shadow owing to the symmetrical position with respect to walls and ceiling). Both disc and sphere can be seen hanging above the statue in Fig. 2; the disc is there shown edgewise. Fig. 1 is a plan of the room showing the position of the camera and the various objects with respect to the walls, and also gives particulars of the window area, from which it will be noted that the daylight illumination is quite satisfactory.

The photograph is reproduced in Fig. 3, which shows the disc with its face towards the camera. It will be seen that, besides the play of shadow in the statue itself, the difference between the disc and sphere is unmistakable. The former appears uniformly white; the latter has a well marked shadow on the lower right hand portion.

Readings of the actual contrast between the brightest and darkest portions of the disc, sphere, and statue were also taken both in daylight and artificial light. It will be seen that although the actual surface-brightness in foot-candles in the respective conditions varied, *the ratio* between the bright and dark portions was, curiously enough, almost exactly the same in both cases.

SURFACE BRIGHTNESS IN FOOT-CANDLES.

Object.	Daylight.		Inverted Arc.	
	Highest.	Lowest.	Highest.	Lowest.
Disc	3·2	3·2	3·5	3·5
Sphere	22·0	2·3	7·6	0·78
Statue	8·32	0·72	2·1	0·22

This room was devoted to modelling &c., and it was therefore an excellent example of a case in which sufficient light and shade were highly desirable. Both the method of experiment and the results are very interesting, and one would like to see the same methods applied to the study of galleries in which statuary is exhibited.

[Since receiving this article we notice a contribution entitled 'Die Schattenbildung und ihre Berechnung,' from Dr. Konrad Norden in the *Elektrotechnische Zeitschrift* for June 22; this will doubtless be of considerable interest to those investigating the shadow conditions of different systems of lighting. In this article Dr. Norden attempts to define the "shadow-power" of such systems more precisely and deduces relations connecting the depth of shadow with the general conditions of illumination, as regards brightness of surroundings, &c. As a result he suggests methods by which the qualities of different installations in this respect may be compared. The present communication deals only with the theory of the subject. Practical examples are promised later, when we hope to return to this subject.—ED.]

Recent Advances made in the Manufacture of Incandescent Gas Mantles.

By Dr. C. Richard Böhm.

In the September number of 1909 of *The Illuminating Engineer* (p. 628, &c.) I dealt with the progress made in the field of incandescent gas lighting, especially with reference to incandescent mantles made of ramie and artificial silk. Soon afterwards I published my investigations regarding the incandescent mantle in book form (W. Knapp, Halle-on-the-Saale, 1910), thus supplementing my work on incandescent gas lighting in general, which, under the title 'Das Gasglühlicht,' was published by Veit & Co., Leipzig, in 1905.

It is beyond the scope of a single article concisely to outline the contents of my latest work, even in the most summary fashion. I will, therefore, confine myself to complementing my 'Notes on Incandescent Gas Lighting' as regards the advances made in the manufacturing methods of the gas mantle.

Among the many kinds of webs, the plain knitted or tricot stocking continues to hold its place as the most practical. Although many different patterns of woven fabrics are likewise being used, it must be said of them that they are, and will always remain, mere fancy articles, in spite of the fact that one is now able to weave the heads conically.

The washing process has been considerably simplified in so far as the raw web used only to be soaked overnight in a cold 2 per cent solution of nitric acid. In the morning the superfluous water is removed by centrifugal action, whereupon the web is for a short time treated with a weak solution of ammonia in order to neutralize the acid. After having been washed out well, first with warm condensed water and then with distilled water, very pure webs, containing only between 0·015 and 0·02 per cent of ashes, are obtained.

There are no alterations as regards the method of impregnation; only some small improvements in the old wringing machine have been effected. The composition of the impregnating fluid has likewise remained the same; for hardening purposes the nitrates of beryllium, magnesium, and zirconium are used as usual.

For strengthening the heads tulle and gauze ribbons, specially made for the purpose in the sizes required, are now being employed instead of the ordinary strips of tulle. By their use, especially by that of the gauze ribbons, a considerable saving can be effected.

Much accuracy, with a consequent expenditure of time and trouble, was always required for the sewing of the so-called spider of the inverted mantle. Nowadays these mantles, even those of the best make, are, with very few exceptions, simply tied up like a bag at the lower end. The bunch of yarn-ends thus produced is then turned inside. Skriwan at Vienna effects the sewing of the spider by means of the sewing-machine. Conically woven inverted mantles have also lately been put on the market.

The agent used for further strengthening the heads of upright mantles is, generally speaking, the same as before, viz., a 50 per cent aqueous solution of aluminium and magnesium nitrate. The nutcracker-like fixing device has been superseded by a rotary fixing machine, similar in construction to a knife-cleaning machine.

The sewing on of the asbestos loop is nowadays almost without exception done by machinery. The Cohn machine seems to be used more extensively than any other for like purposes. This method of working has further been considerably simplified by the introduction of the metal head "Hella."

Asbestos thread drawn through the web is also required for fixing the inverted mantle on the ring. This is another operation which may now be

performed with the aid of the Cohn machine.

The many different patterns of special magnesia rings for inverted mantles, which had been brought out in the course of time, have fortunately been reduced to a few types only. Of these the "Universal" and "Nuo" rings seem to be most extensively used in England, while in Germany the Graetzin ring and the Graetzin method of suspension hold the dominating position.

The magnesia ring, like the metal ring, has proved unpractical for use with upright mantles. On the other hand, it is due to the introduction of the magnesium ring that substantial progress has been made in the sphere of incandescent petroleum lighting. The chief merit in this respect belongs to Langhans, who recognized the advantages of the magnesium ring in this connexion.

The composition of the stamping fluid has likewise remained the same. All efforts to find a method by which the mantle may be stamped after collodinisation have hitherto proved unsuccessful.

The greatest changes which of late have taken place in the methods of manufacture pertain to the incineration and the subsequent shaping and hardening of the mantles. The opinion formerly held that these stages must be left to the manual skill of the female operatives, eliminating all mechanical aid, is now regarded as having been altogether wrong. Naturally, this change of opinion has produced a corresponding change in the working methods.

Great pains have been taken in order to meet the special requirements as regards these important stages in the manufacturing process, on which the life of the mantle and the maintenance of its brilliancy so largely depend. It can, in truth, be said that the various inventors have succeeded in solving the problem, thus further aiding the incandescent mantle industry considerably in its progress. The continually growing world-consumption, which today may be estimated at about 250 million mantles per annum, demands other than manual methods of manufacture. The only way of coping with such large numbers is the use of ingeniously constructed machines. To be more or less independent of factory hands is of great importance, especially to those industries which are concerned with the manufacture of articles in bulk. The changes witnessed of late in the manufacturing methods of the incandescent mantle industry can, therefore, fairly be considered a new departure. Almost every mantle factory, advancing with the times and manufacturing not only mantles for special purposes, but also the ordinary cheap article, possesses to-day one or more burning-off machines. Where formerly extensive workrooms were required for accommodating the large number of picked female workers which had to be employed in order to cope with a given daily output, it is now possible to produce an equal quantity on comparatively small premises, and with the aid of relatively few hands. Moreover, the heat in the former burning-off rooms was so great in summer that fainting fits were daily occurrences, so that the overseers had always to be provided with restoratives, such as ether drops, &c. Statistics also show that the greatest number of consumptives were to be found among the female workers engaged in the burning off of mantles. The reason for this is, after what has been said, not difficult to understand; the continual sitting in a stooping posture as well as the constant inhaling of hot and bad air are, no doubt, very favourable to the culture of the tubercle bacillus. A considerable improvement in the working conditions took place with the introduction of the burning-off machine. With the latter boxed in, and the improved ventilation, the female operators are now protected from the oppressive heat and the unhealthy atmosphere. Their eyes are also guarded, by means of suitable screens, against the glaring light which ten or more mantles, burning under increased gas pressure, are bound to emit. The screens made of neutral glass have proved particularly serviceable.

Whichever hand-worked machine

may be employed, the process is, apart from minor differences, in the main as follows. After the stockings have been shaped on wood-blocks provided for this purpose, they are suspended on rods by means of steel hooks, which should be kept in a box within easy reach. The stockings are then put on the machine, either with or without the rod, but not until the incinerating burners, or else the by-passes, where such are provided, have been lit. The incineration device is now brought in position, enabling the flames to play upon the mantle-heads, whereupon the screen is lowered. When the stockings have burned down half, the hardening burners, which are connected to the high-pressure gas service, are moved upwards inside the mantles up to a point about 1 in. from the heads; meanwhile the gas supply to the incinerating burners is turned low. As soon as the mantle-heads have ceased glowing, after the incineration process has been completed, the high-pressure gas is slowly turned on so that the burners, as yet without great pressure, may light themselves on those of the incineration apparatus. The pressure is now increased to such a degree as is necessary for the proper shaping of the head. In judging the pressure to be applied, due regard has to be paid to the sensitiveness of the web at that particular part of the mantle. The burners are now gradually lowered, whilst the pressure is maintained at the same height. For the second upward and downward movement the pressure should be increased to double its former degree, while, at the third turn, full pressure has to be put on. At this stage the head is, as a rule, somewhat longer exposed to the flame than the other parts of the mantle. The incinerating burners which, with nearly all the modern burning-off machines, are connected to the high-pressure gas service—on account of their being employed for hardening the mantle-heads—are fully turned on as soon as the mantles have been reduced to ashes, so that the flames can play upon the heads during the whole of the shaping and hardening process. It requires from two to three minutes to reduce the stocking for an upright mantle to ashes; with inverted mantles this is accomplished in a slightly shorter space of time. For the shaping and hardening of ordinary mantles $1\frac{1}{2}$ to 2 minutes are required. In the case of inverted mantles at least two more minutes should be reckoned for hardening those parts where the mantle is fastened round the ring. To accomplish this the burner is lowered to a point about $\frac{3}{4}$ or 1 in. below the mantle, so as to direct the full force of the flame upon the ring until it is rendered white hot.

With a view to still greater independence as regards manual labour, efforts have been made aiming at the production of incandescent mantles by mechanical means entirely. Müller and Bonnet, who seem to have been the first to hit upon this idea, took out numerous patents covering the main principles of the invention. A machine constructed on those principles and put upon the market by Robin led to a prolonged action for patent rights, which was settled some time ago.

A number of Robin's machines had, for several years, been in use at Mr. Richard Feuer's works. They gave fullest satisfaction, and were only removed in consequence of the action for infringement of patent rights. Robin himself manufactured mantles on his machines both in England and America. In Germany alone, many millions of incandescent mantles have been manufactured on Robin machines within the space of a few years. When the actions which are still pending have been settled the manufacture of mantles by these or similar machines will again be vigorously taken up. The illustration given may be of interest; it shows the Robin machine, which is exceedingly simple in construction. Both the Robin and the Müller and Bonnet machines perform all the processes required for turning the simple stocking into a completely finished mantle. Whereas Müller and Bonnet employ conical supports for keeping the mantle open at the lower end after they have been reduced to ashes, Robin effects this by using wire rings, which are placed round the bottom of the mantle. The

principle of working is the same with both machines. In either case rods, each holding ten mantles, are conveyed over various rows of burners by means of a chain drive. The mantles are then collodionized and finally trimmed in sets. The two machines are also equal as regards capacity, which, in either case, amounts to between five and six thousand mantles per day.

Collodionising has for a long time been performed by the aid of a dipping arrangement which allows 200 or more mantles to be treated at the same time.

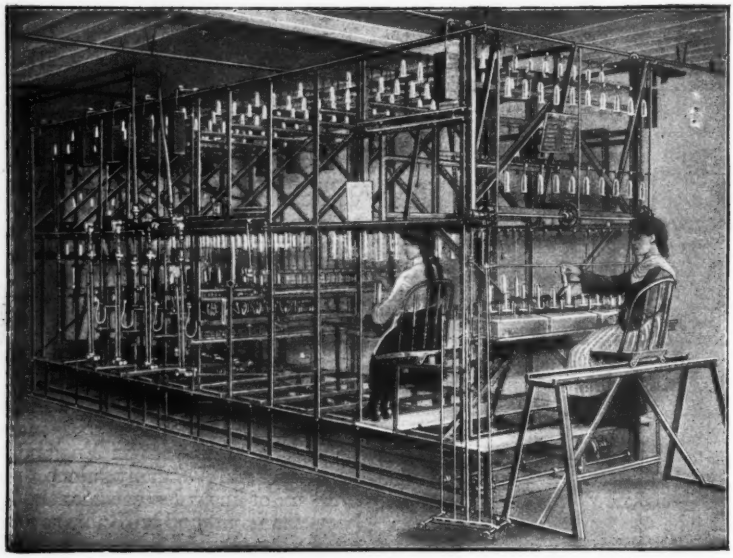


Fig. 1.—"Robin" Mantle-making Machine.

The adding of new ingredients to the dipping fluid has not proved to answer the purpose, as well as Castor oil and Camphor. Nitrate of Zirconium, beryllium, or thorium, added to the collodion in proportions of from 2 to 5 per cent, serves to render the mantle immune from the consequences of lateral pressure, at least for a time, for very soon these drawbacks become again evident. Such makes as "Securitas," "Lederstrumpf," "Pergament," &c., are based on admixtures of this kind.

The trimming of the mantles is still performed in the ordinary way by a cutter consisting of a small rotary knife of circular shape. A sledge-like device introduced by Killing constitutes an exception as regards form, but it seems to have proved a success.

As regards the packing of mantles no changes have to be recorded, at least as far as the upright type is concerned. For the inverted mantle quite a number of new boxes have been devised, few of which have, however, proved a success.

Although the main difficulties connected with the manufacture of incandescent mantles have been overcome, there is still abundant justification for every effort made which tends in the direction of rendering the mantle stronger and more elastic than it is at the present moment. The introduction of mantles made from artificial silk is undoubtedly a great advance in the field of incandescent gas lighting. However, all further endeavours made in order to bring the old idea of producing incandescent mantles by means of threads spun from any plastic substance with incandescent properties nearer its realization have been in vain.

The Lighting of the South London Art Gallery, &c.

By an Engineering Correspondent.

The South London Art Gallery and Camberwell Museum, in spite of its small size, is of interest from the illuminating point of view on account of its being lighted by gas instead of by electricity like most of the other London Museums. The building adjoins the Polytechnic in the Peckham Road. The extent of the whole collection is but two rooms and a corridor.

The first of these is known as the Ruskin Gallery and, except for one statue, contains pictures only, the centre space being kept open for occasional use for social events. This being so, it is evident the light is required principally on the walls, with sufficient provision for general lighting when necessary. The height of the room is about 20 feet, and the walls are a dark red (with strips of wood half-way up on which to fix the pictures) with a dark parqueterie floor. Nearly half the area of the flat roof is glass, so that very good lighting is obtained in the daytime. For evening use there are sixteen 2-light gas pendants which hang in a rectangle parallel to the four walls at a distance from them of 7 feet. The pendants have a spread of 5 feet 6 inches, so that the spacing along the side walls is fairly even—the room itself being 67 feet long by 32 feet wide. Ordinary incandescent mantles are used with bi-passes and, on the side of the burner nearest the centre of the room, an enamelled metal reflector is fixed which throws the light exclusively on to the walls. The height to the mantles from the floor is 9 feet. The effect is excellent—with a possible query as to some of the colour values.

As a contrast, the lighting of the solitary statue mentioned is less satisfactory. On its pedestal it is some 10 feet high, and is almost in contact with the lamp beneath which it is placed. As may be imagined, the outlines of the figure are black and indistinguishable in the shadow of the bottom of the lamp.

At the end of this room is a lean-to corridor, 60 feet by 10 feet, with skylights to the north. The lighting, which is very good, is by a row of 10 incandescent gas lights down the centre at a height of 10 feet.

Beyond this is the Passmore-Edwards Room, which forms the Museum, containing representative specimens of most branches of art in both desk-top and 6 feet cases—many of them lent by the South Kensington Museum. Omitting the stage, which is used for lectures, &c., this hall is about 25 yards long by 12 in width. There is a dark-timbered open roof, 30 feet to the ridge, and only a third of this is glazed. In spite of the lighter walls and floor (the former a dirty buff with red wainscoting half-way up) the room is by no means as well lighted as the picture gallery, and, on a dull day, the objects in some of the cases cannot be properly examined. Unfortunately, matters are even worse at night. Two rows of five 2-light pendants are provided with ordinary mantles 11 feet from the floor. Is it to be wondered at, therefore, that the room compares so unfavourably with the Ruskin Gallery? Each light serves double the floor space of those in the latter, they are higher up, and, instead of the light being required in a horizontal direction (for which the erect mantle is eminently suitable) it is wanted directly below the burners. A great improvement could be effected by the substitution of inverted mantles, but no doubt an increase in total light is also necessary.

The Annual Meeting of the Institution of Gas Engineers.

THE Annual Meeting of the Institution of Gas Engineers is always an important event, and the proceedings on this occasion seem to have been again entirely successful. Many matters of moment to the gas industry were discussed, and we may refer those who would like to follow the papers in detail to the usual exhaustive accounts published in *The Journal of Gas Lighting* (June 20) and *The Gas World* (June 17). In the space at our disposal we can only refer to a few matters of special interest in connexion with gas lighting.

PRESIDENTIAL ADDRESS.

The address of the new President (Mr. Alex. Wilson) contained a summary of the chief events of the year. To those outside the industry, he remarked, it might seem strange that there were still new problems to be solved in connexion with such an old-established business as gas lighting. Yet novel and important advances were still being made, and the old methods were gradually being superseded ; flat flame burners were still being exchanged for incandescent ones, and the saving thus accomplished often amounted to as much as 70 per cent. But what was perhaps even more striking was the progress in the *use* of gas lighting, and the design of artistic fixtures and appliances.

The President then proceeded to refer, among other matters, to the visit of the members of the German Institution of Gas Engineers, which had been such an agreeable feature of the year ; every one was anxious to foster friendly international relations between engineers in different countries. Other events of the year had been the passing of the first of the Standard Burner Bills and the Organization of the Publicity Committee ; this was a natural consequence of the recognized need to come in closer touch with the public and to let it be known what gas lighting could do.

In conclusion, the President referred to the good work being done at Leeds University under Prof. Bone and the immense value of this stimulus to scientific research.

PAPERS AND REPORTS.

There were, as usual, several reports to be presented by sub-committees, including those on Gas Heating Research, Refractory Materials, and Carbonizing ; in connexion with the latter a special report was prepared by Dr. R. Lessing dealing with Continental progress.

The papers presented were as follows :

The Dessau Vertical Retorts at Sunderland. By Mr. Charles Drury, of Sunderland.

The Woodall-Duckham System of Vertical Retorts. By Mr. John P. Leather, of Burnley.

The Scientific Carbonization of Coal. By Mr. J. G. Newbigging, of Manchester.

The Choice of a Carbonizing System. By Mr. P. C. Holmes Hunt, of Melbourne.

The Uses of High-Pressure Gas for Industrial Heating Purposes. By Mr E. W. Smith, M.Sc., of Birmingham.

Public Lighting. By Mr. S. B. Langlands, of Glasgow.

Modernizing a Medium-Sized Gas Undertaking. By Mr. C. F. Broadhead, of Middleton.

Notes on the Corrosion of Service-Pipes. By Mr. James McLeod, of Greenock.

Some Aspects of Gas Supply in a South American City. By Mr. Bernard F. Browne, of London.

The Lecture—Surface Combustion and its Industrial Applications. By Prof. W. A. Bone, D.Sc., Ph.D., F.R.S.

Public Lighting.

The subject of chief interest to readers of this journal is naturally that taken by Mr. S. B. Langlands of Glasgow in his paper on Public Lighting. High-pressure gas lighting in Glasgow has had to await the transformation of a number of flat-flame burners to incandescent ones, but is now making considerable progress.

Much attention is devoted by the author to the question of mantle-renewal and maintenance of street lamps, and only active and intelligent men are picked for this task. Special forms are distributed on which each individual mantle failure, together with the exact nature of the breakage, are entered, so that a full record is kept of the performances of different types of mantles. In passing it may be noted that Mr. Langlands prefers square lanterns to round ones on the ground that any pane which breaks can be readily replaced, and a failure of one pane does not put the whole lantern out of action. Clockwork automatic control of the lighting and extinguishing of lamps has been tried with good effect, and an electrically operated clockwork device is stated to have yielded exceedingly accurate results.

The Value of Illuminating Engineering to the Gas Industry.

What, however, is of greatest interest to us is Mr. Langlands' testimony to the value of the Illuminating Engineering Society. We will conclude by quoting a few of his remarks on this point:—

"One must admit that there is room, ample room, for such a society, and it should be hailed by all gas engineers as a possible source of great help. In no other service perhaps, more than in public lighting of towns of any considerable size, is there need for a specially trained official being in charge. The work should not be, as it too often is, an extra duty performed perfunctorily by an otherwise busily employed chief official of a municipality. Town planning is being discussed and advocated, garden cities are being laid out every day, and one wonders if the public lighting of these is receiving its due meed of attention. Most gas engineers know how very difficult it is to remedy faulty spacing of lamps erected many years ago, how difficult to do away with old privileges or to convince the man with a lamp at his gate that it is in the wrong position. A standard specification might have a real value for such new work; and one could even go the length of saying that lamps can be made things of beauty and of decorative value, as some of the architects in the old days proved."

"Do all gas engineers fully recognize the value of street lighting from an advertising point of view? The means are always at hand in the public lamps of showing what the possibilities of gas as an illuminant are, and when conversation turns on the question of the fragility of gas mantles, as it so often does, an effective reply is surely to hand, when it can be stated that less than a mantle per month, on an average, is sufficient for the public street lamps of a busy city where the mantles are exposed to vibration from traffic and to all the winds that blow."

"In conclusion, the author would remark that big cities and towns have a duty to perform in the way of testing new ideas and inventions, and as lighting inspector at Glasgow he hopes to gradually equip so complete a testing station that all figures given and statements made relative to gas, electric lighting, and kindred appliances may be put to the test. Figures of candle-powers are often given which are manifestly exaggerated, and the keener the rivalry between illuminants the further removed from the truth these figures will probably be."

Some Notes on the Coronation Illuminations.

THE Coronation festivities have come and gone and the streets of London are now beginning to resume their ordinary appearance. The decorations have been carried out on an unprecedented scale, and every effort has been made to do honour to the occasion. We must also gratefully acknowledge that (with the exception of the soaking conditions on the Friday night) the weather has been satisfactory throughout, and the crowds that, undeterred by the elaborate police precautions, ventured to be present at the passing of His Majesty probably saw the processions under exceptionally pleasant conditions.

The present moment may be taken to say a word or two regarding the feature of the proceedings of chief technical interest to readers of this journal—the illuminations. It is interesting to recall that the display of light has long been the traditional means of honouring such occasions as these. Methods may vary, new and more elaborate systems of lighting may replace the more primitive devices of an earlier age, but the principle, the display of light as one of the most precious of human possessions, remains the same. Readers of this journal will recall how in a series of articles in our second volume Dr. M. Gaster traced this practice back to the use of illumination in religious ceremonial and to the even earlier worship of the heavenly bodies.

There are not many novelties to record. The present display has differed from previous ones mainly in the magnitude of the effects produced. These attracted vast crowds, and it is interesting to note the use in the streets of temporary illuminated signs (we believe for the first time used in this connection) bearing the words "keep to the right" stationed in the most congested areas.

The most generally employed style of lighting has been the use of outline-lighting by coloured electric incandescent lamps, and we are still seemingly wedded to this method of decoration. There are, however, a few modifications due to recent developments, such as the occasional use of low voltage metallic filament lamps, and the design of special strips, ready wired with the necessary holders, which enables work of this kind to be done very quickly and conveniently. We also note signs of concession to the view held by some that this system is of a somewhat glaring nature, *e.g.*, the more habitual use of frosted lamps; also the use of reflecting metal "saucers" behind lamps so as to increase the apparent size of the source and spread the light over a larger area, and of collapsible lanterns, paper shades, &c.

A very common device has been the use of coloured miniatures of the King and Queen, of roses, thistles, shamrocks, &c., which are bordered by electric lamps so as to be effective both by day and night. To some extent, however, the method defeats itself. The presence of bright lights round objects of this kind draws away attention from the actual picture and makes it inconvenient to see the details, in spite of the high order of illumination. This effect is less in evidence when frosted lamps are used.

At the same time it will be admitted that the public taste in decorations is in favour of brilliant effects, and that the lavish use of light is still regarded by many as the main essential in festive illuminations. It may also be conceded that although masses of lamps are still often used indiscriminately, there were also instances in which judgment was used and the attempt made to blend the colours of lamps and surrounding decorations in an artistic manner. However, there is need of considerable artistic skill in

the combination of "spot-lights" of various colours and with illuminated draperies.

In the West End.

The quarter of London which attracted most attention was naturally the West End, where many of the clubs had made special efforts to do honour to the occasion. Piccadilly, a brightly lighted locality under all conditions, excelled itself. The Piccadilly Hotel was elaborately decorated with festoons of coloured lamps, and the Criterion Restaurant, with its immense white star on a blue ground, and the ingenious model of a Dreadnought with steam issuing from its funnels, also attracted much attention.

Further west the method utilized on Devonshire House, of concealing lamps amid the foliage of a tasteful display of flowers, also calls for notice, but the rain on Friday evening rather played havoc with this scheme. A simple and restrained method of lighting, by festoons of electrically lighted Chinese lanterns, was adopted at Burlington House, but the effect was rather damped by the brilliancy of the surroundings.

The Royal Institution, in Albemarle Street, was also brilliantly lighted. We are indebted to Messrs. Siemens Bros., Ltd., for the illustration showing the appearance of this building by night (Fig. 1). The installation is considered remarkable for the fact that metallic filament lamps (tantalum), fitted into Bro-ite strip, were used.

Messrs. Hampton's premises in Pall Mall presented a good example of the value of judicious selection of a few harmonious colours, the decorations being in purple and gold, and the lettering executed in blue and yellow coloured lamps. In Cockspur Street, Oceanic House carried an immense white star with 480 lamps emblematic of the shipping company of that name, and an immense illuminated model of the Olympic, the largest steamship in the world. The Canadian Pacific Railway offices displayed illuminated repre-

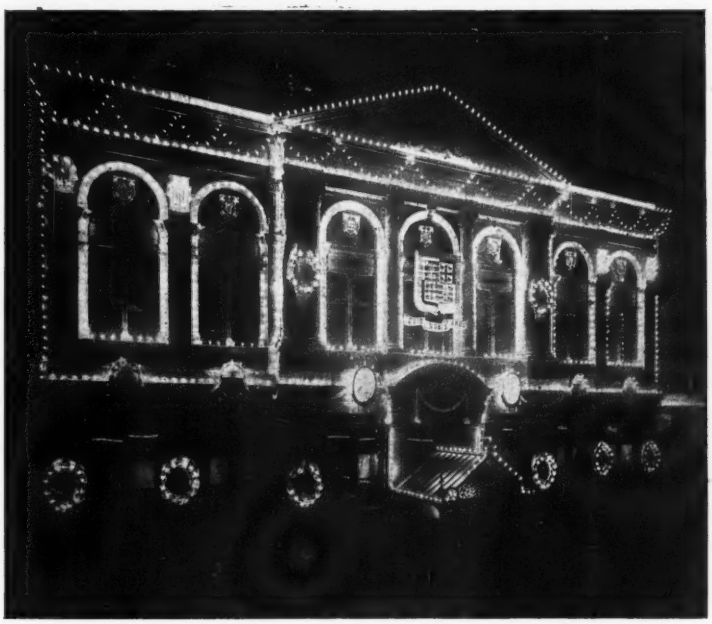


Fig. 1.—The Royal Institution, Albemarle Street, illuminated with Tantalum Lamps.

sentations of four of their engines, the headlights being effectively imitated.

The Clubs.

In "Clubland," it need not be said, the decorations were profuse, almost every building making some form of display. The Carlton Club was decorated with white stars and a huge frosted light medallion bearing the letters "G. R." The Junior Carlton Club relied mainly on floral effects, green, ruby, and yellow lamps being intertwined among the laurels round the pillars. The Automobile Club had also a brilliant display, and the Oxford and Cambridge Club, which confined itself to dark and light blue hangings, produced a tasteful effect.

The display in many of the cases was distinctly artistic, although one felt that even better results might sometimes have been secured by a little more restraint in the use of bright lights and some more perfect means of harmonizing the colours of the silk hangings and the tinted lamps.

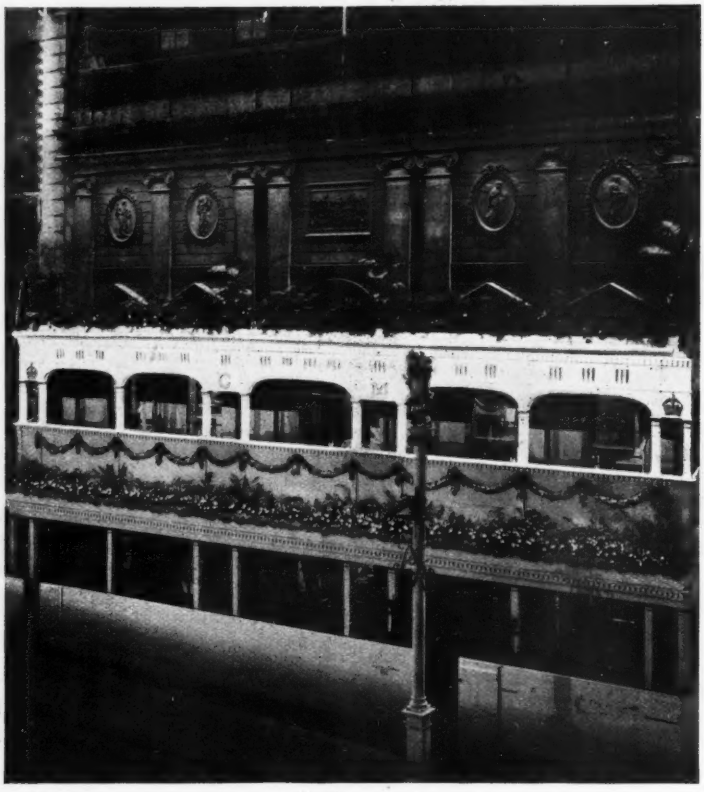


FIG. 2.—White's Club, St. James's Street, the front of which was illuminated with the new Holophane Strip Reflector. The total energy consumption was 3·6 K.W. The exposure for this photograph was determined by means of the Holophane Lumeter.

A distinctly novel method of lighting was, however, adopted in the case of White's Club, in St. James's Street, where the new "picture-lighting" metal reflector of Holophane, Ltd., was shown publicly for the first time. It will be recalled that this reflector,

which was recently described before the Illuminating Engineering Society,* is intended to illuminate large areas; the actual source of light is concealed from the observer, and the light spread out uniformly over the surface by the action of the special contour of the reflector.

The width of the building is about 62 ft. Part of the building face was occupied by a white stand, above and below which two rows of flowers are seen. The face was lighted by two rows of the reflector each 60 ft. long, the total consumption being about 3½ K.W. A feature to be noted was the use of 240 specially designed tubular drawn wire Mazda lamps, made for use with the reflector.

The appearance of the building, when illuminated, may be judged by Fig. 2. Special attention may be drawn to the way in which the flowers are lighted up and the carving on the upper part of the building is shown in relief.

This photograph was taken specially for *The Illuminating Engineer*, the exposure being judged by measurements of the surface brightness of various parts of the building by the aid of the Holophane Lumeter. It is interesting to notice that the surface brightness of the whitest part of the white stand was about 4 foot-candles, and that of the frescoes near the top of the building only 0·25. It will be seen that, in spite of the brilliancy of the surroundings, this illumination quite sufficed to cause the building to stand out prominently. The effect of the light in displaying the carving on the upper part of the building was much admired, and this method may possibly prove of service in the future as a novel means of displaying the exteriors of buildings of architectural distinction.

The cunning arrangement of these reflectors and the concealment of the lamps made it difficult for the uninitiated, at some distance, to tell how the building was illuminated, and the restrained and artistic effect was very effective.

Very little attention seems yet to have been given to methods of lighting up the exteriors of buildings by concealed lights. Yet it has been suggested that this would be most effective in the case of many of the fine buildings recently erected in London. It may be noted, however, that the mere fact of so much light from adjacent clusters of lamps often gave rise to quite pleasing (if accidental) effects of this kind, some of the new Government buildings in Whitehall, for example, making quite a fine picture when seen against the bluish twilight sky.

Other West End Decorations.

In Park Lane the most imposing effect was produced at the American Embassy, where incandescent lamps were lavishly used. What, however, was most interesting was the bronze eagle, which was effectively illuminated by concealed lights in the frame.

Other striking displays were to be seen in Oxford Street, Frascati's being lighted by strings of orange lamps entwined amidst flowers. Selfridges, as shown in Fig. 3, made use of incandescent lamps on a large scale. The upper part of each window was fitted with a golden portcullis, the lines of which were picked out in incandescent lamps. What, however, was probably the best piece of illuminating engineering in the building was the excellently illuminated shop windows; these are a familiar feature, but certainly added materially to the decorative effect.

This photograph was taken specially for *The Illuminating Engineer*. It is interesting to note the manner in which the lights are seen as bright dots, notwithstanding the fact that the exterior of the building is clearly seen; this arises through the fact that the photograph was taken about 8 o'clock, when it was still dusk.

Among other displays in Oxford Street we may mention Marshall & Snelgrove's, and Waring's. In the latter case effective use was made of lights concealed among the window decorations; the

* *Illum. Eng.*, Lond., vol. iii., March, 1911, p. 145.

upper part of the building was illuminated by four quartz tube mercury vapour lamps and the intermediate portion by large yellow lanterns containing high candle-power metallic filament lamps.

The chief items in the Strand and Fleet Street were the displays of the various newspapers and the lighting of Coutts's Bank, where a simple treatment, with the Crown and Cushion as the central feature, proved effective. The arch erected at Temple Bar,

FIG. 3.—Showing decorations and illuminations at the premises of Messrs. Selfridge, Oxford Street. This photograph was taken at dusk, with the artificial lights on, the exposure being determined by means of the Holophane Lumeter.

dividing the City from the rest of London, was decorated by means of small bulb coloured lamps introduced amid the copper decoration work of the arch itself.

Near the Bank of England.

The greatest crowds of all assembled in the neighbourhood of the Bank of England. On the Bank itself over 5,000 lamps are said to have been used,

Another building in this neighbourhood which deserves special mention was the Gresham Life Assurance Co. We are indebted to the General Electric Co., Ltd., for the accompanying illustration of this building, which was outlined in "Pixielite." The main cornice was hung with a garland of lamps and coloured roses, and the piers on the second floor carried white and blue electric flambeaux. The initials

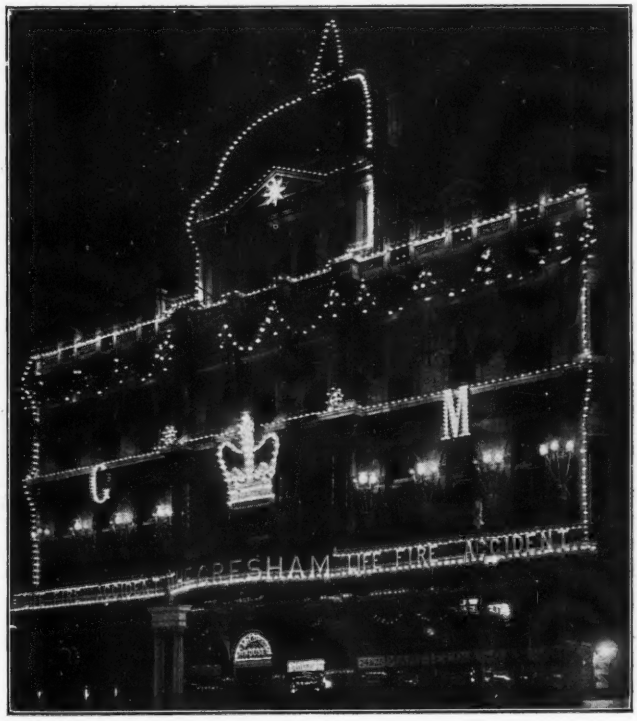


Fig. 4.

Illuminations of the offices of the Gresham Fire, Life, and Accident Insurance Co., Poultry.

the outlines of the building being very closely followed; the Mansion House and the Royal Exchange were also a blaze of light, the method of twining strips of lamps round the pillars of the former being specially effective. The brilliant lighting of many neighbouring buildings, and the festoons of lights in Lombard Street, also attracted much notice.

G. and M. were made up of rosettes and lamps intermingled, and were 6 ft. in height.

Many of the offices in neighbouring streets were also brilliantly lighted, and Fig. 5, for the use of which we are indebted to the British Thomson Houston Co., Ltd., shows a view of the premises of this company in Cannon Street. On this building 700 lights in all were used,

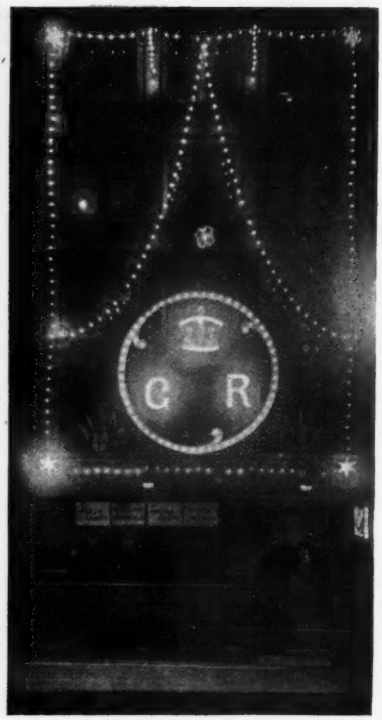


FIG. 5.—Illumination of offices of the British Thomson Houston Co., Ltd., Cannon Street.

the outlining being carried out in amber lamps, and the festoons in white. In the centre will also be seen a kaleidoscopic sign in which a large number of small coloured lamps were used.

GAS AND ACETYLENE DECORATIONS.

Although the majority of the decorations were electric, gas lighting also played a part in the display. The illustration in Fig. 6, for which we are indebted to the courtesy of the South Metropolitan Gas Co., shows the large illuminated sign put up at the Company's works in Vauxhall.

The flickering quality of gas jets has also been considered by some an advantage from a decorative standpoint, since it gives "live" appearance to the device quite distinct from the stillness of the electric decorations. The shimmering effect of such gas flames inside crystal medallions was utilized on many buildings, for example on the Royal Exchange and certain of the banks, a particularly happy effect being sometimes secured by the combination of gas and electric devices.

In addition to these crystal designs open jet pictures were employed in considerable numbers, and an imposing effect was sometimes secured by the occasional use of large gas flambeaux on

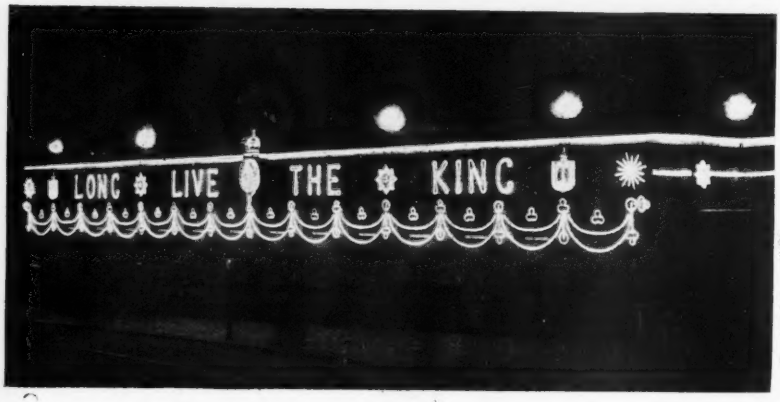


FIG. 6.

Illuminated gas sign outside the premises of the South Metropolitan Gas Co, Vauxhall Road.

the tops of big buildings. Outline lighting with coloured enclosing globes was also employed in some cases.

Some excellent illustrations of these methods are afforded in Figs. 7, 8, and 9, for which we are indebted to the Gas Light and Coke Co. Fig. 7 shows a view of the offices of the company in Kensington High Street, where stars made up of gas-jets, outline lighting by individual burners, and flambeaux at the top of the building are all in evidence. Fig. 8 again illustrates the same method as employed at the premises of the Marine Insurance Co. in Old Broad Street. Fig. 9, which shows the offices of the North British Insurance Co., Threadneedle Street, is an example of the combination of "dot-lighting" with the shimmering crystal devices, internally illuminated by gas flames.

One of the most noteworthy acetylene installations was the tower of Westminster Cathedral, undertaken by the Thorn & Hoddle Acetylene Co. At three days' notice the task of lighting the St. Edward's Tower and the West Front was undertaken, burners to the value of 20,000 c.-p. being employed, and rendering the tower a striking object from a considerable distance. The premises of the company in Victoria Street were also illuminated with festoons of small coloured lamps.

An interesting application of acetylene for decorative purposes, which

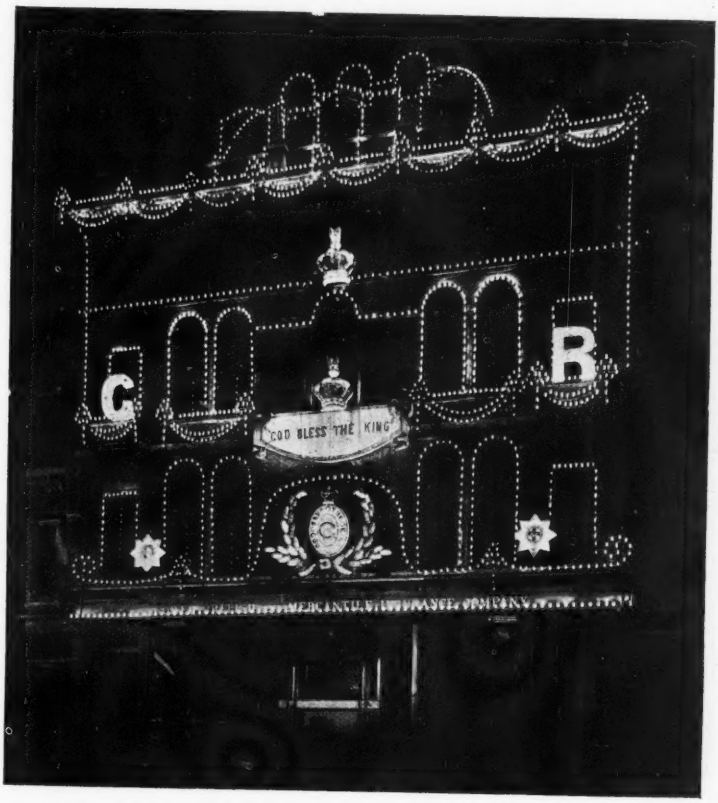


FIG. 9.—Showing offices of the North British and Mercantile Insurance Co., Threadneedle Street, illuminated by gas.

does not seem to have been attempted on this occasion, is the use of the high candle-power flares for illuminating the outsides of buildings ; some of these

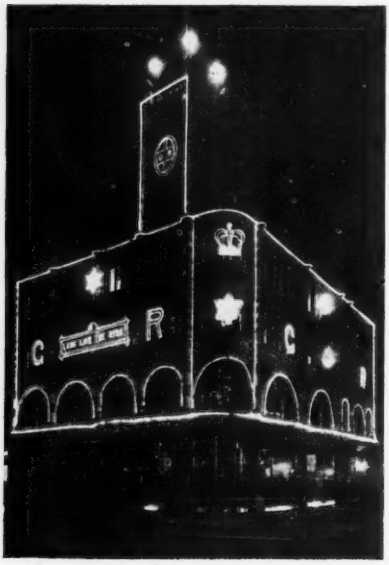


FIG. 7.—Offices of the Gas Light and Coke Co., Kensington High Street.

portable flares were used during the night work on the new entrance to St. James's Park at Charing Cross, and the accidental illumination of some of the adjoining buildings by the concealed lights was distinctly effective. It should also be recalled that the portable nature of these flares, and the easiness with which they can be installed and removed when the display is over, should render them specially serviceable in remote places such as towers and for "searchlight illumination." Possibly had this method been followed in the case of the Westminster Cathedral Tower an even finer effect would have been obtained.

THE NAVAL REVIEW.

The mention of searchlights reminds us that the Naval Review calls for some notice. The illuminations appear to have been of a more or less familiar character, the outlines, masts, portholes, &c., of the ships being picked out in incandescent lamps and searchlights turned on the vessels during their evolutions. One specially interesting novelty utilized in the review seems to have been the illuminated shell. In the past it has always been a difficulty in research on gun-firing that the actual course of a projectile could not be readily followed. This obstacle appears to have been removed by the introduction of a shell with a luminous tail. In war time such shells can be equipped with a time-device which causes a brilliant light to be kindled when the projectile is about to strike the enemy's ship ; thus the target is brilliantly illuminated and the gunner can take more careful aim.

There is one other feature of the Coronation illuminations which must not be forgotten, namely the bonfires blazing on many of the chief heights of Great Britain on Coronation night. In the kindling of these fires we see a reversion to the traditional methods of an earlier age, although doubtless our bonfires of to-day are more scientifically constructed than those which blazed at the accession of Queen Elizabeth !

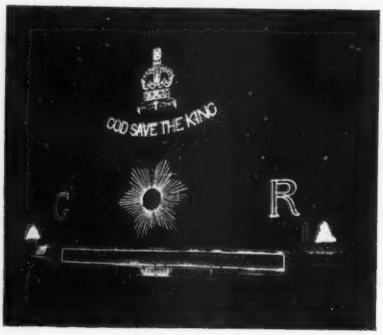


FIG. 8.—Gas illumination devices on offices of the Marine Insurance Co., Ltd., Old Broad St

Some Notes on Restaurant Lighting.

Among the problems facing the illuminating engineer to-day, none is more interesting than restaurant lighting. In each case there are special points to be borne in mind according to the class of business, and the method of illumination adopted has a most important bearing on the prosperity of the concern. Some interesting remarks on this subject were made in a recent number of *Holophane Illumination*, and it occurred to us that some of these particulars would be of interest to readers of this journal.

Fig. 1.

Showing Illumination of Table d'Hôte Room, *Cabins Restaurant*, Strand, London, W.C. Tungsten Lamps and Holophane Glass Reflectors covered by silk shades are employed.

Most managers of restaurants, it is pointed out, would admit the truth of the suggestion that the lighting is an extremely important item. But it is not always understood quite *how* important it is. In reality, there is perhaps no other factor which is so influential in determining the first impression of a customer. The provision of good illumination is, in a sense, a "hall-mark." Tasteful conditions of lighting not only act as an inducement to a customer to enter an unfamiliar restaurant for the first time, but they also impress him with a sense of its high standard and possibly lead him to overlook deficiencies by which he would at once be struck, in poorly lighted premises. The pleasure of dining in a fashionable restaurant is not only derived from the good fare, but is also very largely due to the pleasant impression received through the eyes during the meal. In fact, the expense in such cases is often mainly determined by the costly and elaborate scheme of the decoration, and the choice furniture, plate, flowers, &c. Who can doubt

that the appearance of such a room is to a great extent dependent on the way in which it is lighted? The illumination of a fashionable restaurant is an art in itself.

In considering the general problem of lighting restaurants, tea-shops, &c., the article continues, one finds there are several quite distinct cases. Some tea-shops, for example, cater largely for those of the public who "drop in" for a few minutes to have a cup of tea, but have not much time to spare. In such cases a bright, general illumination is needed, partly to attract attention from the street, and partly because such casual visitors usually prefer brightly lighted surroundings.

On the other hand, there are other concerns which devote themselves rather to the more leisured classes; in this case it is tacitly understood that customers are at liberty to spend a longer time over their tea and, indeed, utilize the opportunity for a chat. The lighting is therefore naturally of a somewhat different character. The intention is rather to produce an impression of subdued light, and the lights are arranged to produce and give a "cosy" character to the room. These two classes of business are quite distinct and the lighting engineer must be able to appreciate the nature of the case and plan the illumination accordingly.

The same considerations apply with even greater force to restaurants. Here, the time which the visitor proposes to spend on the meal is the controlling factor in the situation. If his visit is only a short one, a bright general illumination is essential. Such a condition not only satisfies the customer best, but is naturally of assistance to the staff in enabling them to deal with orders promptly, to keep touch with customers in all parts of the room, and in removing dishes as quickly as possible, &c. But when the customer intends to linger over a meal —when he takes this opportunity of meeting friends, and for conversation—haste is undesirable, and dining proceeds in a more deliberate manner. The customer then prefers more subdued and cosy conditions, and the method of separate tables in little alcoves is very commonly adopted. The system of illumination is also of a quieter kind, well shaded table lamps which throw a good light on the table, but leave the surroundings in partial shadow being commonly employed.

The first essential, therefore, is that the illumination should suit the needs of the situation.

As an example of enterprise in methods of illumination the lighting of the *Cabins Restaurants*, situated in various parts of London, is quoted.

A typical restaurant is that in the Strand. In the basement which is intended rather for customers of the occasional class, Holophane reflectors and tungsten lamps are utilised, the idea being in this case to produce a strong general illumination of a cheerful character. The reflectors are specially selected with a view to distributing the light over the side-tables as well as the centre ones, and a very good and even illumination has been secured. Recent measurements with the Holophane Lumeter showed that the illumination on the tables was of the order of 3 to 5 foot-candles, while the consumption of electrical energy is not more than half a watt per square foot—a remarkably low value in view of the excellent illumination secured.

A somewhat different method of lighting has been employed in the upper floor where the table d'hôte course is served. This is one of the cases in which customers like to dine in a more leisurely manner, to meet friends, and to utilize the opportunity for conversation, &c. The general scheme of illumination is therefore preferably of a more subdued character; a strong illumination is shed on the tables, but the surroundings are left in comparative shadow. The method of illumination adopted is shown in Fig. 1. Chandeliers carrying tung-

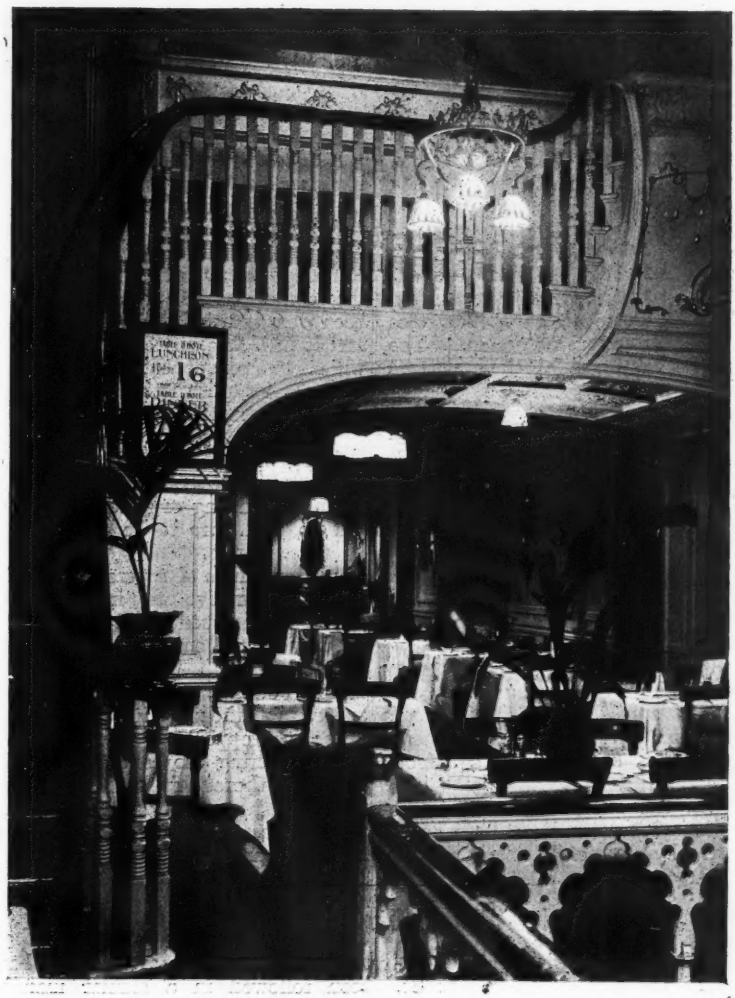


FIG. 2.

Showing method of Illumination employed on the Ground Floor of the *Cabins Restaurant*, Piccadilly, London, W. The Central Chandelier in the Foreground is equipped with Tungsten Lamps and Holophane Reflectors; in the recess in the background similar reflectors, covered by crimson silk shades, are used.

sten lamps and Holophane reflectors, covered by crimson silk decorative shades, are employed, and there are also silk-shaded table lamps.

The advantage of this method is obvious. By using Holophane reflectors the majority of light is thrown downwards in an efficient manner, while only a small amount, just enough to illuminate the silk effectively and to provide a subdued light for the surroundings, is allowed to escape sideways. In this way it is possible to secure all the advantages of scientific distribution of light and also to use silk shades for their decorative value. The concentrating power of the reflectors employed allows smaller candle-power lamps to be used than would otherwise be necessary, so that a substantial economy is made through their use.

Fig. 2 shows the ground floor of the restaurant near the corner of Piccadilly Circus. This is interesting as an example of the combination of the method employed in the other two cases mentioned. In the foreground will be seen a chandelier carrying Holophane reflectors and tungsten lamps, and the lighting near the front is of a bright general character, the illumination on the tables being again of the order of 3 to 5 foot-candles.

But in the background recess the Holophane reflectors have been again covered by tasteful crimson silk shades and the illumination is more subdued. The contrast between this portion of the floor and the bright foreground is most effective.

It is stated that, in making alterations in these premises, severe economy had to be practised, and it was considered essential to make use of existing wiring, fittings, and outlets as far as possible; so that the installation was rather in the nature of the best compromise which the conditions allowed. Notwithstanding such restrictions, however, the conditions of illumination have been substantially improved. The article in *Holophane Illumination* from which we are quoting asserts that on the average quite twice as much light as that formerly available has been provided, and yet an economy in the lighting bills of 30 to 40 per cent has been made.

The consulting engineer and Messrs. Cabins, Ltd., are to be congratulated on these results.

In these days of severe competition, it is imperative to introduce the latest improvements and to study the needs of customers even in the smallest things. We understand that Messrs. Cabins, Ltd., have recently redecorated the majority of their branches; the opportunity was naturally taken to bring the conditions of illumination thoroughly up to date, and no pains have been spared to make the various shops and restaurants as attractive as possible.

The Electric Lighting of St. Mary's Church, Redcliffe.

THE method of electric lighting employed in the famous church of St. Mary's, Redcliffe (Bristol), furnishes an interesting example of the grafting of the new on to the old. This church is renowned for its associations and beautiful old interior, and it might naturally have been expected that there would have been some hesitation in introducing modern illuminants.

The method adopted has been to outline the arches on either side of the main aisle with clear bulb metallic filament lamps, and in some cases the straight lines of the architecture have been followed in a similar manner. By this means the lamps are kept out of the direct range of sight, and the brightly illuminated stone immediately behind them probably serves to tone down the contrast between their brilliancy and the surroundings; but one would have supposed that objection might have been raised to the system on æsthetic grounds.

In addition to these lamps there are chandeliers equipped with imitation metallic filament candles.

The Illumination of Caves and Grottos.

By An Engineering Correspondent.

One very fascinating branch of decorative lighting is the illumination of caves and grottos. Perhaps the most famous of all are the Mammoth Caves in Kentucky (U.S.A.) A correspondent sends us an illustration showing the method of lighting these by means of small oil canisters. Fig. 1 shows these in the act of being strung together by the guides. In addition to these small oil lamps the guides also carry wadding or cotton waste steeped in oil in tin pails on their backs; the blazing material when attached to metal canes serves as torches. With a deftness borne of long experience, the guide will also jerk pieces of the flaming stuff on to adjacent shelves and niches so as to illuminate the vast caves in any desired direction.

Fig. 1.—The Guides arranging the small oil canisters used in lighting the Famous Caves at Kentucky (U. S. A.).

famous caves at Cheddar in Somerset. The methods of lighting up these famous show places differ considerably. In many cases the only available illumination is provided by a lantern or candlestick carried by the guides, and the dim light adds considerably to the impression of insecurity on the part of nervous tourists; it is naturally

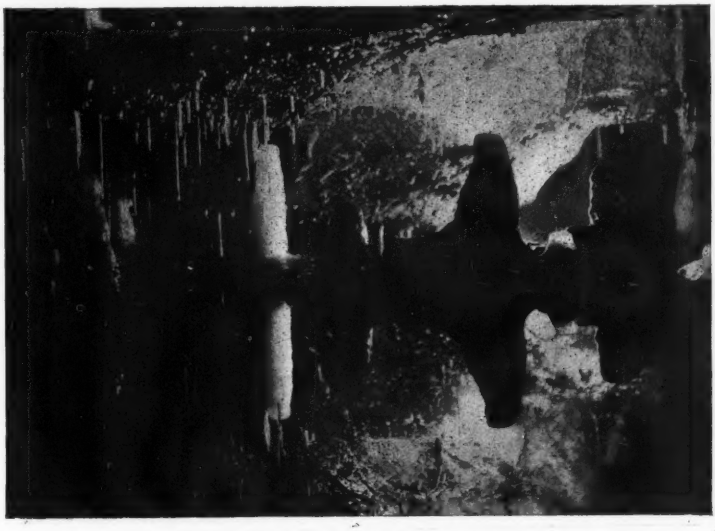


Fig. 2.—Fairy Grotto, Gough's Caves, Cheddar (Lighted by electricity).

There are also quite a number of interesting caves in the British Isles: for example, the immense subterranean galleries at Ingleborough and the

easier to slip on uneven floor, or to knock one's head against projections overhead under these conditions, and lack of illumination is sometimes necessary to the sense of adventure which forms a feature of such entertainments.

FIG. 3.—Gough's Stalactite Grotto, Cheddar (Lighted by electricity).

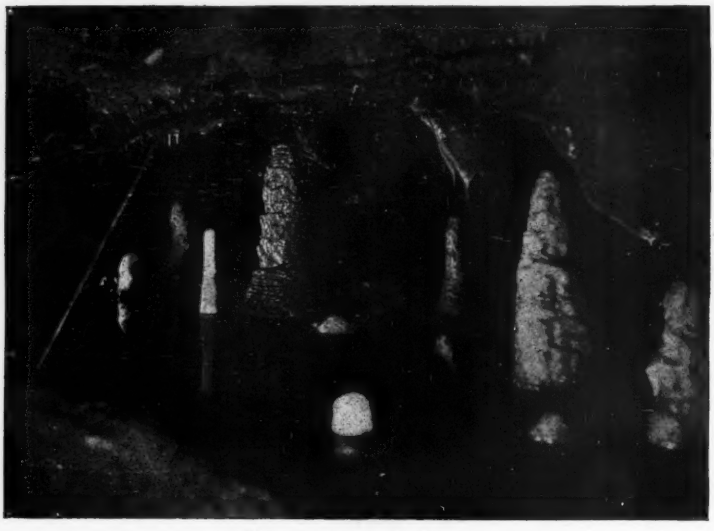


FIG. 4.—The New Grotto, Gough's Caves, Cheddar (Lighted by electricity).

there is always the fear of what might happen should the lights go out! On the other hand it may be urged that the It must, however, be confessed that very little of the caves themselves can be seen under these conditions, and

a candle or oil lamp is naturally of little service in illuminating the vast walls of many of these huge caverns.

The display of the curiosities that fringe the walls or hang overhead is often an art in itself, and it therefore occurred to the writer that a word or two about the methods of lighting employed in two famous caves at Cheddar might be of interest. One of these, "Gough's Cave," which was first discovered by the late Mr. R. C. Gough in 1877, is lighted by electricity by the aid of a special 10 K.W. dynamo driven by a small gas engine on the premises. From a little shed containing the plant, which is just outside the cave, mains are run through the various caverns. Metallic filament lamps, cunningly arranged behind the rock, serve, in an admirable manner, to display the glittering stalactites. Many fairy-like effects are produced in this way both glowlamps and arclamps being employed for the purpose. Besides the wonderful effect of the play of light on the shining surface of these curious stalactites, the lamps serve to bring out the transparency of many of these delicate traceries; the light is allowed to pass through the translucent material and the colours are beautifully displayed by this means. At certain points in the cave, when, for example, the roof of "Solomon's Temple" or "The Diamond Stream" are reached, the visitors are electrified by the sudden switching on of the light. In several cases alternative lighting effects can be produced by a throw-over switch, so as to put into circuit different groups of lamps.

FIG. 5.—The Transformation Scene, Cox's Cave, Cheddar (Lighted by Acetylene).

Some typical effects are shown in Figs. 2, 3, and 4. In Fig. 2 the wires leading to one of the lamps will be noticed on the left hand. In some of the largest caverns enclosed arc lamps are also utilized.

A feature of the wiring arrangements is that two complete separate circuits are arranged so that, should one fail, the cave will not be left in darkness. There is, however, yet another stand by, for a gas pipe is led through the cave and fitted with burners at frequent intervals.

There is a second smaller but very fascinating cave known as "Cox's Cavern." In this case a small "Luby" acetylene generator is used; burners are distributed through the cave at various points, in some cases controlled by distance lighting apparatus. The white colour of these lights is considered admirable for displaying the delicacy of colour, ranging from red to violet, which is a feature of this cave, and the singular and fantastic growths by which the visitor is surrounded. Some idea of the antiquity of the caves may be gained from the estimate that it takes *2,000 years* for the formation of half an inch of stalagmite deposit. The fairy-like appearance of some of these glittering columns, when so lighted up, is seen in Fig. 5, and the cunning manner in which the water is utilized for reflection is specially interesting. One of the pipes carrying the acetylene gas is also to be seen in Fig. 4, and near the centre of the photograph there is an acetylene burner flanked by a metal reflector and illuminating the more distant regions of the cave. In this way the stalactites are illuminated, but the eye itself is screened from the direct light on the best illuminating engineering principles. The attendant also carries one of these reflectors, in order to focus the light conveniently on any desired spot and draw attention to any special object.

It may safely be said that the beauty of these caves would never have been so fully appreciated but for the clever use of artificial light, which in many respects resembles the devices employed on the stage. One other point which naturally appeals to illuminating engineers is the variety of methods of illumination employed in cavern lighting—gas, electricity, acetylene, oil, and candles being all encountered in various localities. In conclusion the writer would like to express his indebtedness to the proprietors of Gough's and Cox's caves for kindly furnishing some of the illustrations accompanying this article.

Neutral Absorbing Screens for Photometry.

A RECENT paper by H. E. Ives and M. Luckiesh in the *Physical Review* (May) describes an interesting new form of neutral absorbing glass. Most of the smoked and tinted varieties absorb too selectively (unduly favouring certain colours) for them to be safely used in spectrophotometric work. The glass devised by the authors consists in opaque line-ruling, the absorbing power being proportional to the amount of space left dark and light respectively. For fine ruling a reduction of 1·4 can be obtained by this means, for coarse ruling more. The accuracy attainable is said to be amply sufficient for photometry, and the glass is strictly neutral. The method, however, is only conveniently applied when the light is allowed to illuminate a diffusing surface, as in an ordinary photometer. The grating is then merely inserted between the source and the photometer screen.

Natural Gas in India.

THERE is, according to a note in *The Gas Industry*, a large supply of natural gas near Chittagong, in India, which has been burning from crevices in the ground for such a length of time that the oldest inhabitant does not know when it was started. Recently it has been suggested that the fire be extinguished and the gas be brought in pipes to Chittagong for purposes of light and power.

Short Notes on Illuminating Engineering.

From all Sources.

Public Decorations—Co-Operation Needed.

UNQUESTIONABLY, individual buildings here and there were made the most of, but in most cases the effect was much marred by the discordant or trumpery character of the attempts on adjacent premises. It was astonishing how many instances there were of comparatively important buildings where money had been spent in quite lavish fashion with the most mediocre result. As is generally admitted, we have a lot to learn from the foreigner concerning street decorations, and the progress made is painfully slow. The only rational way of decorating the streets of a great city on a momentous occasion is by some system of co-operation.—*The Financier*, June 27, 1911.

The Best Surface for Blackboards in Schools.

A CORRESPONDENT sends us some particulars of his experience in arranging for the lighting of a blackboard in one of the classrooms of a well-known technical institute.

The board in question was 24 ft. long and 6 ft. high, and composed of linoleum coated with matt spirit varnish. It was experimentally lighted by two 3-burner Graetzin inverted gas lamps with white blotting paper reflectors behind them.

It was found, curiously enough, that a board which was rather dirty (*i.e.*, on which traces of chalk remained) was better than a perfectly clean one. Both the lecturer and the students agreed that it was easier to see the white chalk figures under these conditions, and both long-sighted students and short-sighted students agreed on this point. Some measurements were taken with the Holophane Lumeter, and it was found that the mean illumination was 2 foot-candles; the surface-brightness of the white chalk was 0·8, of the dead black background 0·06, and of the chalk smudged portion 0·3 foot-candles respectively.

One would naturally expect that the best definition would be secured with the greatest contrast between chalk and blackboard, and it would be interesting to know the reason why the writing apparently "stood out" better with the somewhat grey surface. One suggestion that has been made is that although the contrast is less the amount of glare, in the form of direct shiny reflection, is lessened by a thin film of chalk. The point is an interesting one, and deserves further investigation.

Popular Lectures on Illumination.

THE Civic League of St. Louis has entered on a course of popular, free lectures on social and municipal subjects, which is to be commended. Naturally, a question as intimately joined with common life affairs as is that of illumination will be included among the subjects treated.—*Acetylene Journal*, June, 1911.

The Embankment Lighting.

THE lighting of the north side of the Embankment roadway has been greatly improved recently by the substitution of Beckflame arc-lamps for the older types formerly in use; the effect is admirable, the view along the Embankment at night being very picturesque. The arc-lamps on the parapet, which are really intended rather for ornament than for the practical purpose of illumination, are to be replaced by large tungsten lamps, and the lower halves of the dioptric globes, which are difficult to clean properly, will be of plain glass. These lanterns, it will be remembered, were originally designed for gas, and this is their second conversion. The changes are being carried out by Mr. C. A. Baker, electrical engineer to the County Council.—*Electrical Review.*

A New Standard Gas Burner.

A STANDARD gas burner has recently been devised by M. St. Claire Deville embodying, according to a note in *L'Industrie du Gaz*, certain features which are a distinct improvement on former standards. The chief point appears to be that the admission of air to the outside of the flame is controlled by a valve, the position of which is indicated on a graduated scale, so that the whole amount of air supplied to the burner can be controlled and measured. It is also claimed that this type of burner is not unduly favourable to any particular quality of gas.

Illuminating Power of Gas and Factory Requirements.

A POINT of great interest to the gas industry came up for discussion in the evidence before the Departmental Committee on Accidents in Factories,* namely, the illuminating power of gas used in factories. At the present time gas is largely used for incandescent purposes, consequently the claims of a calorific standard in place of an illuminating one are receiving wide recognition, even though it is realized that such a radical change must proceed gradually. Substantial reductions in the illuminating power have already been made in certain districts. Yet there are certain cases in which, rightly or wrongly, flat flame burners are still being employed, and where such a reduction in the illuminating value may prove inconvenient. In the evidence referred to Mr. J. H. Rogers, District Inspector of Factories in Birmingham, alluded to a deterioration in the illumination in certain factories, where flat flame burners were extensively used, apparently because movable lights were considered essential. It was pointed out to him that Parliament had sanctioned the diminution in candle-power of the gas from 20 to 14, so that no claim could be made against the gas company for this reduction.

One finds an impression in some factories that mantles cannot satisfactorily be used owing to vibration, &c., but sometimes the considerable improvement in strength and shock-resisting power of modern mantles, particularly those of the small inverted type, is not sufficiently appreciated. If, however, it does prove necessary really to use flat flame burners, the illumination should be specially well cared for, as an offset to any diminution in light which a lower candle-power might bring about.

* See *Illum. Eng.*, July, 1911.

A New Electric Lamp.

A NEW electric lamp was recently described before the Académie des Sciences which is a modified form of mercury vapour arc. According to some particulars given in *The Revue des Éclairages*, the arc is formed in vacuum between an anode of tungsten and some mercury at the other end, and is struck by means of a small electromagnet which brings the tungsten anode and mercury into contact. The light emitted is said to be remarkably white, combining as it does the blue of the mercury arc with the whiteness of incandescent tungsten. The energy consumption is low, being given as 0·45 watts per candle. The lamp as at present arranged works at a pressure of 12 volts, but it is hoped that this value may be increased by the use of some inert gas in the bulb.

REVIEWS OF BOOKS.

LECTURES ON ILLUMINATING ENGINEERING.

(A series of lectures delivered at the Johns Hopkins University during October and November, 1910, and now published by the Johns Hopkins Press, Baltimore, U.S.A., in two volumes.)

We have referred previously to this unique series of lectures, giving the full programme and the list of eminent authorities by whom they were delivered. The promised volumes containing the published account are now to hand. It is unnecessary to repeat what we have already said as regards the comprehensive scope of the lectures, and readers are referred to our previous remarks on this subject.

It only remains to be said that these two volumes constitute a most valuable record, and will doubtless furnish material for the advanced student for some years to come. Every effort seems to have been made to bring the contents up to date, and to render the record as comprehensive and complete as possible. Each of the two volumes before us contains over 500 pages. Vol. i. contains the first ten lectures, which are mainly devoted to the more technical aspects of illuminants. After several introductory lectures on the physical nature of light, electric, gas, and oil lighting are successively dealt with, the concluding part of the volume bearing mainly on the measurement of light and illumination and units and standards.

The second volume, containing the remaining eight lectures, deals rather with illuminating engineering practice. There are again several introductory lectures, on the physiological and psychical aspects of the subject, and then the principles of interior and exterior lighting, shades and reflectors, fixtures, &c., are discussed. Finally, two lectures are devoted to the commercial aspects of gas and electric lighting, and the volume concludes with a brief account of the experimental course.

The volumes are well indexed, and a specially good feature is the complete syllabus preceding each lecture. It may be added that most of the lecturers have recognized the impossibility of dealing fully with their subject, even in the considerable space here placed at their disposal; they have therefore supplemented their lectures by a bibliography of the various available papers on the subject. These references will doubtless be found of much service to students, and will add considerably to the value of the whole.

ELEKTRISCHE BELEUCHTUNG.

By Dr. B. Monasch.

Dr. Max Janecke, Verlagsbuchhandlung, 89b Osterstr. Hannover. Germany. 9m. 20. *New Edition,* 1910.

This is a new edition of the excellent work of Dr. Monasch, which appeared in 1906 and has been previously reviewed in these columns.* The author remarks on the considerable progress that has been made in all departments of illumination during these four years, and he has therefore brought the book up to date by an additional special section of nearly 100 pages, in which new developments are recorded. This addition is divided into three parts dealing with photometry, arc-lamps, and glow-lamps respectively.

In the photometrical section such matters as the agreement on the international unit of light, the methods of Bloch, Wild, Kenelly, Sumec, and others for calculating mean spherical candle-power, the Blondel-Krüss integrating photometer, &c., are summarized, and the new recommendations of the Verband deutscher Elektrotechniker are reproduced.

The arc-lamps section is brought up to date by an account of the Jandus regenerative enclosed lamp, the magnetite and titanium carbide arc-lamps, the quartz tube mercury vapour lamp, &c. The glow-lamp section deals more fully with metallic filament lamps, and contains an account of the deposition, paste, and colloidal methods of making tungsten

* *Illum. Eng.*, Lond., vol. i., 1908, p. 252.

filaments; special attention is also given to recent life-tests, and to progress in knowledge of the theory of radiation and luminous efficiency. An additional index has also been provided.

The value of the work has been substantially increased by this timely addition, and this section of the book alone provides interesting reading as a review of new developments. No one studying this can fail to be struck by the increase in the rate of progress during the past four years.

DAS ACETYLEN, SEINE EIGENSCHAFTEN, SEINE HERSTELLUNG, AND VERWENDUNG.

By Dr. J. H. Vogel.

Edited by Dr. Ferd. Fischer of Göttingen. Verlag von Otto Spamer, Leipsic.

This work, which belongs to the series of publications dealing with various special aspects of chemical technology, edited by Dr. Fischer of Göttingen, is devoted largely to the physical and chemical problems connected with the generation and use of acetylene. The author has also received the co-operation of Dr. A. Levy, Dr. P. Wolff, Dr. A. Schulze, and Herr A. Schneider, all of whom are specialists in certain departments of the subject.

The book contains nearly 300 pages, and deals with the whole subject in a most exhaustive manner. A specially valuable feature is the complete series of references to the work of other authorities and the liberal use of tables comparing the results obtained by investigators in various countries. Most of the chapters deal mainly with the chemical aspects of the subject, the generation and purification being exhaustively treated. A special chapter is also devoted to dissolved acetylene, and the various processes of autogenous welding are treated in great detail. Acetylene burners, both open flame and incandescent, also receive attention; and we notice a serviceable table in which the data from various sources regarding the efficiency of burners are collected. The hygienic aspects of acetylene also receive a chapter, reference being made to the effect of ultra-violet rays and their influence on the eye.

The use of acetylene gas for heating and cooking is described, and also some special applications, such as the value of acetylene, in the laboratory, for producing various chemical reactions of industrial importance, &c.

The concluding portion of the book contains a reprint of the Prussian regulations regarding the use and storage of acetylene, and the various technical recommendations of the German *Acetylen Verein*. There is also a short summary of the available literature on the subject, and an adequate Author's and Subject Index.

We do not doubt but that the book will be found a most valuable one by engineers and students.

HIGH EFFICIENCY ELECTRICAL ILLUMINANTS AND ILLUMINATION.

By R. W. Hutchinson.

Messrs. John Wiley & Sons, Ltd., New York; Messrs. Chapman & Hall, Ltd., London.

As the title suggests, this work is concerned exclusively with electrical illuminants. The greater part is devoted to descriptions of various forms of lamps; thus of the 278 pages in the book, pp. 16–113 deal with glow-lamps, pp. 114–187 with arc and vapour lamps, and a considerable section of the remainder with shades, globes, and reflectors.

Regarded as a record of recent American literature on these subjects, these chapters may be found of service.

We think, however, that in a future edition the author might profitably either extend or omit certain sections devoted to the principles of photometry and illumination. Such matters as the mechanism of the eye, the meaning of candle-power, flux of light, illumination, the use of illumination-photometers, &c., which are here very cursorily dismissed, require specially lucid and careful treatment in order to be intelligible to a beginner.

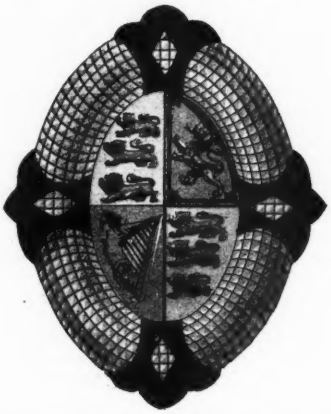
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

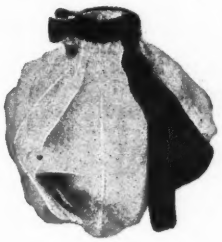
Coronation Illuminations.

ELSEWHERE in this issue we have described and illustrated some of the noteworthy features of the recent illu-



minations, in which electricity, gas, and sometimes both illuminants in combination were utilized with good effect.

Several firms have sent us illustrations of schemes of illumination carried out by them, and some of these we have reproduced in the article just referred to. **Messrs. Siemens Bros. Dynamo Works, Ltd.** (Tyssen Street, Dalston, London, N.E.), have also given us particulars of some of the special devices which



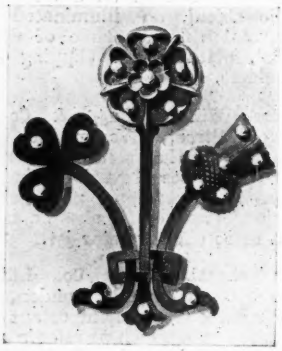
were supplied by them. The accompanying illustrations show an effective heraldic shield, an illuminated torch device, and a floral shade of fireproof material, suitable for clipping on to lampholders.

Messrs. William Sugg & Co., Ltd (Regency Street, Westminster, S.W.), inform us that they sold a large number of gas-jet devices of various kinds. In addition to the ordinary plain jet, most of their devices could also be supplied with a more effective star jet.

The General Electric Co., Ltd. (67, Queen Victoria Street, London, E.C.), also carried out some important installations, to one of which we refer in another section of this journal. Their catalogue, illustrated in colours, shows a large variety of letter and scroll devices, frequent use being made of torches, with glass "flambeaux" containing a glow lamp.

Simplex Conduits, Ltd. (113–17, Charing Cross Road, London, W.C.), in addition to their illumination strip, brought out a modified form of lamp holder, specially designed for temporary wiring in conditions which would not admit of the ready-wired system.

The illuminated crown, supplied by **The British Thomson-Houston Co., Ltd.** (83, Cannon Street, London, E.C.), and illustrated herewith, is a good example of this form of decoration. The elaborate nature of the design in carving and relief, may be judged from the illustration, and we understand that the crown was painted correctly according to heraldry. It formed an important feature in the scheme of illumination designed for the Company's offices, and illustrated on page 474.



The same firm also used a rose, thistle, and shamrock device, an illustration of which is reproduced.

Theatre Dimmers.

The Adams Manufacturing Co., Ltd. (Bedford), have sent us an elaborate descriptive catalogue of their "IGRANIC" DIMMERS FOR STAGE LIGHTING. These are designed on the circular contact principle, the resistance elements being completely covered by a cement composition. A special feature is the rigid driving rod, which enables the dimmer to be controlled with certainty of action, even if it has to be installed at some distance from the switchboard. The catalogue also describes interlocking devices and a wheel-drive mechanism, the latter enabling one man to operate any combination of plates so as to dim certain lights and brighten others at the same time. This is especially useful in obtaining a slow degree of change as is required in dawn, twilight, and similar effects.

Patent Reflecting Lamp.

WE notice among other features in a list of METAL FILAMENT LAMPS supplied by the **Corona Lamp Works Company** (Ascham Street, London, N.W.), a description of their patent "METAFLECT" LAMP, which has been specially designed for the lighting of shop windows, picture galleries, &c., where the light is required to be concentrated in a particular direction. The lamp is fitted with a flattened glass cover silvered on the back, the curvature being such that a large part of the light from the lamp is concentrated in an approximately parallel beam. The results of a test made by the National Physical Laboratory are given, and appear to show a considerable increase in the intensity of the light along the axis of the reflector.

The Benjamin Electric, Ltd., announce that Mr. Guy Campbell, formerly Sales Manager of Holophane, Ltd., has joined their Company. New offices and show rooms have been opened at 117, Victoria Street, Westminster, S.W., but the works and warehouse are at 1A, Rosebery Avenue, E.C., as before.

The Benjamin Electric, Ltd., has purchased the stock and goodwill of C. F. Trippe, of 36, Brooke Street, Holborn, E.C., and all communications should be sent to the new offices of the Benjamin Electric, Ltd., at 117, Victoria Street, S.W. It is the intention of this firm to manufacture, among other produces, specialities necessary for efficient industrial lighting, and further particulars will be given to the trade in due course.

An Inverted Burner for Street Lighting.

The "ZEIMAR" BURNER, shown in the accompanying illustration, has been specially designed by **The Ramie Co., Ltd.** (Bredbury, near Stockport), for street lighting purposes. It has a plain steel enamelled case with a good regulating

nipple, and it is claimed that 28 candles per foot of gas, at 2-2¼ inches pressure, have been obtained on gas from the Stockport mains, whilst as much as 30 candles per foot is said to have been obtained elsewhere.

We have previously referred to the KALKOS TINNED TUBE SYSTEM of **Messrs. Sun Electrical Co., Ltd.** (118–20, Charing Cross Road, London, W.C.). They ask us to mention that the Kalkos Iron Box is now universal, *i.e.*, for surface, flush and semi-flush, and that it is designed for use with switch, ceiling rose, wall socket, bracket, &c.

High Pressure Oxy-Acetylene Welding.

The Acetylene Illuminating Company (268-270, South Lambeth Road, London, S.W.) have sent us a pamphlet giving some particulars of their HIGH PRESSURE OXY-ACETYLENE WELDING PLANT, and the accessories used in conjunction with it. Among the latter may be mentioned the special Cutting Blowpipes, in which a separate jet of Oxygen is arranged for cutting metal plates. The standard type supplied by this firm is claimed to be capable of dealing with steel plates up to six inches in thickness.

Oil Incandescent Lighting.

The Kitson Empire Lighting Co., Ltd. (Stamford, Lincolnshire), send a small booklet drawing attention to the economy, adaptability, and safety possessed by their system of INCANDESCENT LIGHTING WITH VAPORIZED PETROLEUM. The self-contained type of burner, in which the oil is supplied from a small tank above the lamp, is mentioned as being specially suitable for public fêtes, &c., where it can be installed without any elaborate system of piping. We understand that they are now offering their lamps at reduced prices to clear stock, and they have sent us particulars of their designs for a large variety of purposes.

We have received a SOUVENIR OF THE CORONATION NAVAL REVIEW from **Messrs. Bell's United Asbestos Co., Ltd.** (Southwark Street, London, S.E.), in which are tabulated many details of the various ships assembled together, with photographs of the chief types. It is pointed out that in practically every ship the boilers were fitted with joints specially designed by the above Company.

Some Publications Received.

Journal and Transactions of the Junior Institution of Engineers.—This contains a report of the paper on 'Illumination by Gas and Electricity,' by F. J. Hawkins, to which we referred in our last issue.

We have also to acknowledge the receipt of the following: *Proceedings of the Physical Society, Journal of the Rontgen Society, Journal of the Royal Society of Arts, Proceedings of the American Institute of Electrical Engineers, American Chemical Journal, Transactions of the American Electrochemical Society, Journal of the Franklin Institute, Proceedings of the American Academy of Arts and Sciences, Jährbuch der Radioaktivitat und Elektronik, Zeitschrift fur wissenschaftliche Photographie Photophysik und Photochemie, Atti della Associazione Elettrotecnica Italiana.*

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

THE question raised by Mr. Haydn T. Harrison in *The Electrician*, and referred to in the last Review of the Technical Press, is now taken up in the article by MR. J. ECK (*Electrician*, June 23), entitled **Light and Shade in Indirect Lighting.** Some photographs are shown explaining the difference in the appearance of a flat disc and a sphere of similar material in a room lighted with inverted arcs, and numerical data are presented to show that the intensity of shadow is very similar to that which would prevail by daylight. The matter is also discussed in subsequent letters in the same journal for June 30th and July 6th.

K. NORDEN (*E.T.Z.*, June 22nd) contributes an article on the same subject. He points out that illumination from a single point source would give complete density of shadow, while completely diffused illumination would give no shadow at all. These conditions, however, are both rare in practice, and in general we have to deal with a mixture of diffused and direct lighting. The author goes on to suggest that precise methods of distributing the amount of shadow in installations are needed. He defines diffusion, and depth of shadow, and discusses how the degree of shadow cast by several sources should be calculated. The present article deals with theoretical aspects of the subject and practical applications are to follow.

There are a number of articles of scientific interest which have appeared in the United States. P. G. NUTTING gives some recalculations of the luminosity curve based on Koenig's data. He shows that the most efficient light at ordinary illuminations is secured by using radiation of wave-length 0·545μ. H. E. IVES (*Electrical World*, N.Y., June 15th) also gives some revised figures for the **Greatest Possible Luminous Efficiency.** As a result of the most recent knowledge he suggests that 26 candles per watt might possibly be obtained for white light, and 65 candles for light of a yellow-green tint of wave-length 0·545μ. The same author gives some particulars of **Neutral Tinted Absorbing Glasses in Photometry.** There are few reliable methods of reducing illumination without altering its colour, and it is suggested that finely ruled gratings might often answer this purpose.

Among other articles of the same kind we may note the editorial comments on the **Reflecting Power of Metals** (*Electrical World*, N.Y., June 15th). The qualities of a metal as a producer of light are shown to be closely connected with its reflecting power; what is needed is a metal which reflects infra-red energy well. Tungsten and Molybdenum prove the most favourable materials from this standpoint, but there is still room for research on alloys. There are, again, several interesting illustrated articles in *The American Illuminating Engineer*, notably the account of the methods of **Illumination on Board the Olympic**, the biggest steamship afloat, and the contribution by R. F. PIERCE on some examples of **Restaurant Lighting in Germany.** R. SCOTT (*Electrical World*, N.Y., July 1st) gives an account of the lighting of a restaurant in New York. A special form of globe, the upper part of which is prismatic and the lower frosted, was used. Data regarding the illuminations are given; the values are unusually high, ranging from 6 to 12 foot-candles.

We may also note several articles dealing with **Shades and Reflectors** in the English press. Thus C. TOONE (*Elec. Rev.*, June 16th, 23rd, 30th), completes his article on this subject. He analyzes the functions of shades, commenting on the value of the prismatic method as a means of directing light, and also gives a complete table of intrinsic brilliancies. Very few of the illuminants, he points out, come near the figures which have been given by various authorities for the smallest permissible intrinsic brilliancy.

Turning next to Continental contributions we may note first the important announcement in *L'Officiel* for June 16th regarding the formation of a French Government Committee to discuss the **Hygienic Aspects of Lighting.** (See also *Le Moniteur de l'Industrie du Gaz*, June 30th.) This announcement is noticed elsewhere in this number. W. WEDDING (*E.T.Z.*, July 6th) gives some

particulars of the work of the Photometrical Committees appointed by the Verband deutscher Elektrotechniker. He mentions that researches have been carried out on **Diffusely Reflecting Plates** for measuring illumination, and on materials for coating the inside of the Ulbricht globe. He also refers to the question of comparing sources of light of different colour and illuminants with very extensive radiating surfaces; these problems will have to be dealt with on international lines very shortly.

H. PUDOR (*Z.f.B.*, June 30th) makes some comments on the **Æsthetic Aspects of Exterior Lighting**. The general tendency has been to imitate the architectural lines of buildings too closely with strings of electric light; he also considers the imitation of rosettes, &c., and various glow-lamps as inartistic. Seeing that so many different forms of illuminants and shading devices are now available, there seems ample field for greater ingenuity in producing artistic effects.

ELECTRIC LIGHTING.

Among articles on electric glow lamps we may note that BOURELLY (*Soc. Bellge Elect.*, Bull., 28, pp. 165-173, May, 1911) describes a **New Form of Metallic Filament Lamp**. The ordinary type is apt to be fragile, and does not distribute enough light downwards. In the "Leila" type described by this author, the filaments are sometimes arranged horizontally, or a combination of vertical and horizontal filaments is employed; he claims that besides improving the distribution of light, this method gives rise to greater strength since shorter lengths of filaments have to be supported. P. F. FISHER (*Elec. Journ.*, June, 1911) also deals with incandescent lamps, giving some complete diagrams, enabling the conditions to be determined under which commercial glow lamps should be used in order to get the greatest efficiency, with various prices for electric current. G. DETTMAR (*E.T.Z.*, June 29th, July 6th) deals generally with **Indoor Electric Lighting**, concluding by a summary of the qualifications which lamps for the ordinary householder should possess.

The article by L. CROUCH in *The Electric Review* is now concluded. The author gives a table showing the watts per square foot, obtainable by the use of various electric illuminants for street lighting, and concludes with a diagram of costs for the United Kingdom. Other articles deal with some of the Coronation Illuminations in the Provinces, a notable device being the use of illuminated tramcars.

GAS, OIL, ACETYLENE LIGHTING, &c.

In connexion with gas lighting, one of the chief contributions has been the paper by H. E. COPP ((*G.W.*, July 1st). The author discusses in detail the question of the **Relative Merits of Upright and Inverted Burners**. This is receiving much attention just now. The *Zeitschrift für Beleuchtungswesen*, in describing some new forms of upright mantles (June 30th, July 10th) takes the view that the advantages of the inverted over the upright mantle are apt to be overestimated. H. E. Copp also makes some remarks on the shaping of reflectors for street gas-lamps. These should be convex and not concave, so as to distribute the light sideways. The author also gives the results of some investigations on the use of dioptric globes with gas lamps as a means of modifying the natural curve of light distribution. The paper concludes with a series of polar curves of different types of lamps.

S. SNYDER describes an interesting example of a **Library Lighted by Gas**, a combination of general lighting and local shaded lamps being used (*Prog. Age*, July 1st). A feature is the use of special anti-vibration devices on the table fixtures.

A. SCHEIBLE (*Elec. Rev.*, June 17th) discusses the elaborate gas lighting of the People's Gas Light and Coke Co. in Chicago. The lesson to be drawn from the exhibition, he suggests, is that gas fixtures can now be made quite as attractive as electric units; the great need is for simple and reliable distance lighting methods to be available.

Other articles deal with examples of gas spectacular Coronation lighting in various parts of England.

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Light and Heat in Artificial Illumination (*J.G.L.*, June 24).
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Tungsten Street Lighting in Shreveport (*Elec. Rev.*, N.Y., June 24).

GAS, OIL, AND ACETYLENE LIGHTING.

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Bullock, B. F. Lighting of a Window (*Prog. Age*, July 1).
Copp, H. E. Street Lighting from a Practical Point of View (*G.W.*, July 8).
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Coronation Illuminations (*J.G.L.*, June 27; *G.W.*, July 8).
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CONTRACTIONS USED.

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G. W.—*Gas World.*

Illum. Eng., N.Y.—*Illuminating Engineer of New York.*

J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*

J. G. L.—*Journal of Gaslighting.*

Z. f. B.—*Zeitschrift für Beleuchtungwesen.*

9

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

The Meeting of the International Photometric Commission.

THE third meeting of the International Photometric Commission since its origination took place in Zürich last July, and on pages 507–514 of this number we give a summary of the proceedings. It is very evident that the scope of the Commission is extending rapidly. Apart from certain questions which are mainly of technical interest to the gas industry, such as the desirability of a calorific power standard, &c., there are now many questions connected with illumination which are forced upon its notice. A number of striking papers by various authorities were read on this occasion, and to these, too, we make reference elsewhere.

What, however, was perhaps the most important step taken at this meeting was the recognition that the Commission should be in a position to deal with matters connected with illumination not merely from the gas standpoint but from the standpoint of the lighting industry as a whole. We understand that it has now been decided to make the Commission more truly international by providing for fuller representation of the countries concerned, and to secure the co-operation of members of the electrical industry. It is pointed out that such matters as the choice of symbols, units, and nomenclature in illumination are of interest to representatives both of gas and electric lighting, and should, if possible, be settled on lines agreeable to both.

The International Photometric Commission may in the future be in a much better position to give an authoritative ruling on these points. But it must be pointed out that there are quite a number of bodies, notably the Illuminating Engineering Societies in the United States and Great Britain, the Verband deutscher Elektrotechniker

in Germany, the International Electrotechnical Commission, &c., which are also interested in the subject.

To avoid overlapping and possible confusion, therefore, it seems to us that something should now be done to arrange for concerted action. If it complied with these requirements the International Photometric Commission might well become the centre of a new International body in a position not only to deal with photometrical matters, but also to organize researches on such matters as the colour of illuminants, their hygienic effects, &c., all of which present problems of some industrial importance. The original intention of the Commission seems to have been simply to deal with scientific problems connected with gaslighting. Since its inception it has, however, found that photometric matters demanded an ever-increasing share of its attention, and we think it would be rendered capable of even greater service if the chief bodies interested in lighting by various illuminants and the national laboratories were permanently represented. The Commission at present meets at intervals of four years, but it might be assisted by sub-committees meeting more frequently in the different countries, and we feel sure that the Illuminating Engineering Society would be very willing to give their support to such a scheme.

A paper dealing with this matter is to be read by the writer at the coming Exhibition of Applied Electricity in Turin. Meantime we trust that the various bodies interested will give this matter their attention so that a suitable international committee may shortly come into being.

The Annual Congress of the Royal Sanitary Institute.

It is naturally gratifying to observe the attention given to illumination at the Congress of the Royal Sanitary Institute which has just terminated at Belfast, and at which the Illuminating Engineering Society was officially represented by its Hon. Secretary and Mr. J. Darch. Originally four delegates were nominated, but the President and Mr. Justus Eck found themselves at the last minute unable to be present. The paper by Mr. J. Darch revealed a concensus of opinion that the methods of illumination employed in hospitals might often be considerably improved. The lights in the wards are not infrequently so placed as to be inconvenient to the eyes of patients, and there are other defects which could probably be avoided by a little care in choosing the positions of lamps, and in selecting suitable methods of shading. We are constantly laying stress on the importance of the hygienic aspects of lighting in daily life, and it should not be necessary to point out that these aspects are, if anything, even more vital in an hospital. Patients are very easily affected by prejudicial conditions which a healthy person might ignore. One frequently notices arguments on the comparative cost of different methods of lighting for hospitals, but it may be suggested that a little more care as regards the proper use and the hygienic aspect of the matter might be exercised by hospital authorities. In the case of the operating theatre the importance of well-designed illumination is particularly obvious, and the surgeon's skill ought never to be hampered by insufficient or badly directed light. There can be no question that there is still much to be learned on this point, and we may select this subject as one on which the co-operation of the medical profession and lighting engineer would doubtless be especially beneficial.

The second paper of interest to our readers is that by Mr. W. H. Webb on the planning of school rooms. In the course of this paper special reference was made to the question of lighting. The author concluded by referring in complimentary terms to the discussion on the subject by the Illumin-

ating Engineering Society last April, and reproduced for the benefit of those present the chief conclusions arrived at.

We regard this as a gratifying illustration of the way in which the work of the Illuminating Engineering Society is constantly being studied by experts interested, and the results made known to other influential bodies. By the adoption of these recommendations by hygienic and scholastic authorities, a steady improvement in the conditions of school lighting should result, and the Society may expect to see its labours bearing useful fruit.

It may be added that there are many other matters which might well receive attention from the Royal Sanitary Institute. One of the speakers in the discussion referred to the insufficient illumination of soldiers' barracks—a question which seems to call for investigation. In the last few numbers of this journal, we have repeatedly drawn attention to the keen discussion, both in this country and abroad, on the illumination of factories. It is now time that hygienic authorities placed good lighting in the same position as good ventilation, fresh air, and sanitary requirements, and we hope that the Royal Sanitary Institute will take this matter up and use their great influence to impress this point on the authorities.

As an illustration of the amount of specialized attention that is now being bestowed on industrial hygiene, we should like to refer to two new journals, 'Human Engineering' and 'The Journal of Industrial Safety,' which we have just received from the United States. The first of these is concerned mainly with the welfare of employees and the hygienic aspects of industrial employment. The second deals with the causes of industrial accidents and the efforts that are constantly being made to secure improvements in this respect. Both journals lay special stress on the importance of good illumination, and we feel sure that among other industrial hygienic requirements, this question will take a prominent position.

Illuminating Engineering and Drawn Wire Tungsten Lamps.

On Wednesday, August 16th, a number of representatives of the technical and daily press availed themselves of the invitation of the British Thomson Houston Co., Ltd., to visit their works at Rugby, one of the chief matters of interest being the exhibition of the newly introduced drawn wire Tungsten lamps.

We have commented upon this improvement in our columns before, and our readers are aware of the improvement secured by this discovery of a method of producing ductile tungsten wire for lamp filaments. It is stated that the mounting in the bulb of these filaments can be done with greater ease and simplicity, and that the use of a single length of wire, instead of short portions supported at intervals, leads to a great improvement in strength and durability. We can now instal lamps in the positions we choose, and transport them from place to place in full confidence that they will not be broken except by actual carelessness—a very different state of things from that prevailing a few years ago.

What, however, we appreciated most was the announcement that a special Illuminating Engineering Department has been formed, and it is intended to combine the business of supplying metallic filament lamps with the policy of studying the methods of using them to secure good illumination. Experimental model installations will, as far as possible, be arranged free for probable large consumers, who will thus be led to recognize that bad illumination means waste and that good conditions do not necessarily mean greater expense. Such demonstrations should do much to educate the general public to appreciate and demand good illumina-

tion. Their attention will also be constantly drawn to modern improvements in lighting, and this will doubtless prove beneficial from the business point of view.

This policy seems to us a wise one, especially in view of the fact that the Company benefits by the services of experts, both in this country and in the United States, who have had extensive experience of the matter.

Mr. Willcox also made the announcement, on the occasion of this visit, that combinations of lamps with suitable Holophane reflectors are now to be supplied. We see here an indication of the growing tendency to regard the lamp and its shade or reflector as a single unit. This idea is doubtless destined to gain ground in the future. The lamp by itself is only an imperfect method of illumination. As a rule it must be supplied with a form of reflector, so as to make the distribution of light exactly what the local circumstances require, and, if need be, to screen the filaments from the eyes and avoid glare; these results the Holophane globes and reflectors are intended to attain. In each case the variety of reflector best suited to the local conditions can be selected, and the benefit derived from this judicious use of illuminating engineering principles will doubtless be as great, or even greater, than that due to the employment of more efficient sources of light.

Photography and Illuminating Engineering.

The question of securing satisfactory photographs of artificially lighted interiors is one that is bound to be encountered by many of those interested in illuminating engineering. The appeal to the eye is now a potent factor in all trades and professions, and photographs, lanterns slides, and illustrations generally are considered absolutely essential in connexion with most descriptive matter to-day.

But in the case of illuminating engineering there is a special reason why this should be the case. It is by the impression derived through the eye, quite as much as through photometrical tests, that we judge lighting installations, and a good photograph is invaluable as a means of explaining to an audience what the conditions of illumination are really like. The use of both methods in conjunction, photographs, and tests of the illumination, together afford an excellent record of the lighting conditions, and this is coming to be thoroughly recognized by up-to-date firms concerned with lamps and lighting.

On the other hand, the taking of photographs of this kind presents special difficulties, especially when it is desired to obtain the same by the actual light of the illuminant employed, and to show both the sources and fixtures themselves and the distribution of illumination in the room. One still sees too many instances in which the appearance of the lamps themselves is lost in "halation," and the picture itself gives no true impression of the distribution of light. A photograph of this kind, so far from proving an inducement to consumers, may actually prejudice them against a given system of lighting. On the other hand, an attractive picture of a good installation is an asset to any company.

The difficulties connected with taking successful photographs of artificially lighted interiors are dealt with in an article by Mr. J. S. Dow and Mr. V. H. Mackinney in this number. Apart from its main object the article serves to show the close connexion existing between the kindred arts of photometry and photography, and it is evident that this constitutes yet another field for beneficial co-operation.

LEON GASTER.

Review of Contents of this Issue.

THE TECHNICAL SECTION (p. 501) opens with an abstract of a paper by E. C. CRITTENDEN entitled **Some Notes on Flame Standards.** The author first refers to the difficulty of using standard candles owing to their variability, and gives curves showing the variation of a sperm candle and a pentane lamp during ten minutes. The Elliott kerosene standard has, he considers, much to be said in its favour as a working standard, especially in regard to its steadiness and its being little affected by weather. In concluding, the author refers to the modified form of pentane standard lamp now being developed in America, the chief feature of which is that artificial means of promoting evaporation by means of an electric heating coil are adopted; the draught is thus independent of the heat of the flame itself.

Some further replies to the list of questions on the subject of **Street Lighting Specifications** appear on p. 504, including some comments by Dr. H. Krüss, and a communication from the Austria-Hungary Gas Association.

A summary of the principal points discussed at the session of the **International Photometric Commission** held at Zürich in July last will be found on p. 507. The proposed enlargement of the membership of the Commission so as to make it more representative is referred to, and some account is given of the discussions on 'Photometry and Nomenclature.' Following this is an abstract of the paper presented by Messrs. W. J. BUTTERFIELD, J. S. HALDANE, and A. P. TROTTER on **Corrections for the Effects of Atmospheric Conditions on Photometric Flame Standards.** The researches described were made in a room specially arranged so that the conditions of the surroundings could be varied at pleasure and the results recorded. From experiments carried out in this way it was found that the correction for pressure in the Harcourt lamp agreed with that previously deduced by Paterson, but for the Hefner lamp it was suggested that Liebenthal's figure of 0·1 per cent for the effect on the light of a change of 10 mm. in pressure should be modified to 0·4 per cent. Corrections were also determined for the effect of humidity and vitiation of the atmosphere, and in conclusion the results are summarized in the shape of general formulæ. Two suggestions of DR. STRACHE are next dealt with: the one referring to a method of defining the **Absolute Unit of Light,** and the other a device for **Adjusting the Hefner Flame** by means of a thermo couple and a galvanometer. On p. 514 is a brief description of a technical form of **Spectro Photometer** introduced by J. THOVERT.

A communication on the subject of **Street Lighting by Gas on the Continent** appears on p. 515. The development of high pressure gas lighting in Berlin is traced, and the merits of high pressure air and high pressure gas systems are discussed at some length. Photographs showing public lighting in Berlin and some examples of centrally suspended gas lamps in Stuttgart are reproduced.

Some account of the **Congress of the Royal Sanitary Institute,** recently held in Belfast, is given on p. 519, with an outline of the discussions on two papers dealing with the lighting of hospitals and schools respectively. In both cases reference was made to the work of the Illuminating Engineering Society, and the need for joint action in connexion with hygienic lighting was insisted upon. A paper on **Hospital Lighting** by J. DARCH, read at this Congress, appears on p. 521. The author deprecates the indiscriminate use of inappropriate shades,

and gives some examples of good and bad methods of illumination in hospitals. In the ward, he points out, it is important to shield the patient from the radiant heat of the light over the bed as well as from possible glare. He illustrates some systems of lighting designed for the operating theatre, and draws attention to the importance of emergency lights in this department. In conclusion he urges that the lighting of the dispensary has not usually had sufficient attention, having regard to the importance of the work carried on there.

Some additional details concerning the **Lighting of the Horniman Museum** are given by MR. C. A. BAKER on p. 528, and the steps that have led up to the present arrangement are traced. The notes conclude with a description of the installation that has been provided for the new lecture hall and library now being erected adjacent to the Museum.

The Value of Photography in Illuminating Engineering is the title of an article by Messrs. J. S. Dow and V. H. MACKINNEY (p. 529), in which it is pointed out that photography may be of great assistance to the illuminating engineer by preserving a record of the appearance, distribution of light, nature of fixtures, &c., in any scheme of illumination. The authors proceed to consider the difficulties met with in judging the exposure of photographs, which point is of special importance if it is desired to demonstrate some particular feature of light and shade. The Holophane Lumeter has been found very useful in estimating the exposure required for a given interior by measuring the surface-brightness of the most important objects in the field and calculating from these values. It is, however, necessary to make a correction for the actinic power of particular illuminants. Some possible applications of colour photography are also mentioned.

On p. 536 is a note on the lighting installation at Gatti's Restaurant in the Strand, which is quoted as an **Interesting Example of Restaurant Lighting.** The two illustrations accompanying the article are intended to show the different styles of illumination adopted in the rooms according to the particular use to which they are put. The main restaurant is, for example, provided with a good general illumination, such as would attract the casual visitor, while in the *table d'hôte* room the idea has been to make the lighting more subdued and restful, as would be desired by a person intending to dine in comfort and converse with friends. Some data are given regarding the exposure of the photographs, which was determined by the method indicated in the article on photography previously referred to.

Following the section devoted to **Short Notes on Illuminating Engineering** (p. 539) will be found an account of a recent visit of members of the technical press to the lamp works of the British Thomson-Houston Co. at Rugby, where an opportunity was afforded of seeing the manufacture of the new **tungsten drawn wire lamps.** At the subsequent luncheon Mr. Sparborg gave some account of the qualities of the new lamp, and briefly traced the stages which had finally led to the production of a drawn tungsten filament. But the fact was emphasized that success depends not only on securing a good lamp, but on using it in the right way, and the company are therefore establishing an illuminating engineering department, so as to be able to advise their customers on matters of illumination.

An important announcement regarding a series of 12 lectures on illuminating engineering, to be delivered at the Polytechnic, Regent Street, London, during the coming winter, will be found on p. 506.

The number concludes with the usual **Trade Notes** and **Review of the Technical Press**

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Some Notes on Flame Standards.

(Abstract of paper by E. C. Crittenden presented at a meeting of the Philadelphia section of the Illuminating Engineering Society (U.S.A.), April 21, 1911.)

IT will be recalled that at the 1910 Convention of the Illuminating Engineering Society in America a report of the work on flame standards carried out at the Bureau of Standards was presented, a brief summary of which appeared in this journal.*

STANDARD CANDLES.

The author at the commencement of his paper refers to the use of standard candles, and suggests that, owing to their simplicity and convenience, they may well be used still where only very approximate results are required; but at the same time he draws attention to the wide variation in flame intensity commonly met with in standard candles. A curve is given showing this variation during ten minutes with a typical sperm candle (see Fig. 1), in comparison with that of the pentane standard.

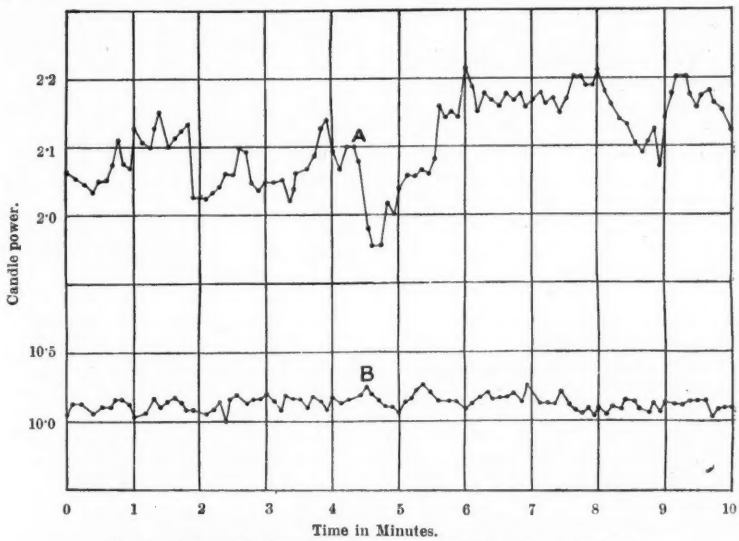

FIG. 1.—Variation in flame intensity of standard candle and pentane lamp.
Curve A = Standard candle; Curve B = Pentane lamp.

Mr. E. C. Crittenden has recently given some further details in a paper before the American Illuminating Engineering Society,† from which the following notes are taken.

* *Illum. Eng.*, Lond., vol. iv., Feb. 1911, p. 77.

† *Trans.*, Amer. Illum. Eng. Soc., vol. vi., May, 1911, p. 417.

Such curves as this have been previously obtained by a sensitive bolometric arrangement, and it is interesting to note that in this case the readings both for the candle and the pentane lamp (also reproduced) were taken by a photometer with an automatic recording device. All of the candles tested showed similar variations in flame intensity, there being a difference of over 5 per cent between the averages of two batches.

ELLIOTT KEROSENE STANDARD.

The Elliott kerosene lamp has considerable advantages as a working standard, chiefly on account of its steadiness and the fact that it is but slightly affected by the weather. With due attention to the chimney and wick, and the exact constitution of the oil, the lamp may be depended on to remain constant within a fraction of one per cent through a whole day, and the author thinks that it is possible to make it " repeat day after day, with a variation considerably smaller than that of the candles which are usually used for its calibration." As an illustration of the accuracy which may be obtained when using the lamp under the best possible conditions, it is worthy of notice that out of 116 measurements made by the author and set forth in a table only two differed from the mean by more than 2 per cent. The colour of this lamp approximates very closely to that of ordinary illuminants, and as measured by the Ives colorimeter closely resembles that of a carbon lamp at 4 watts per candle, the only common illuminant which is better in this respect being the coal gas flame, which is practically identical in colour with a carbon lamp. Owing to its comparative steadiness, it is suggested that the kerosene lamp might be found useful in photometry as a comparison lamp to be left unchanged at one end of the bar.

THE HEFNER LAMP.

The Hefner lamp has three defects which, the author thinks, render it unsatisfactory as a working standard. These are its unsteadiness, reddish colour, and small candle-power. However, three lamps of this kind, recently supplied from Germany and tested at the Bureau, gave mean values of 1·002, 1·003, and 1·005 International candles respectively, these being in closer agreement than the values previously recorded for three similar lamps, viz., 0·9975, 1·000, and 1·002. It is stated that difficulty is experienced in obtaining amyl-acetate which fulfils all the requirements of the specification, especially with regard to distilling over between certain temperatures.

HARCOURT PENTANE STANDARD.

This difficulty of fuel is again met with when dealing with the Pentane standard, although the variations due to impurities are hardly large enough to be of concern in ordinary practical testing. For example, with the worst sample of pentane supplied to the Bureau, which had a density of 0·641, the candle-power produced was only 1·25 per cent too high.

As regards differences between individual lamps when burning under the same conditions, the author refers to the maximum difference of 2·5 per cent, mentioned in the report at the 1910 Convention, and now discusses more fully the effect of the construction of the various parts of the lamp on candle-power variation. The air circulation in the chimney and lamp standard has an important influence on the flame. The chimney becomes hot first, and there is a strong upward draught and the flame is broadened ; but as the lamp standard, through which the air flows down, becomes warmer, the temperature difference between the two columns of air is less, and with a decrease of draught the flame becomes narrower. This effect, it is suggested, is greater in the American lamp than in the English form.

Again, it is contended that the effect on the flame of the flat radiating plate depends largely on whether this is brazed to the standard as in the English lamp, or only loosely connected to it as in the American type. In the latter case, a change in the radiating power of the plate, and therefore a variation in the flame, might result fron an accidental change in contact between the plate and the standard.

The method of supporting the inner chimney is a feature which tends to make the American lamp higher in candle-power; for, since the chimney is supported near the bottom in the American lamp, and at the top in the English, the reduction in height due to expansion on heating is less in the former type.

In conclusion, mention should be made of the new type of pentane lamp which is being developed at the Bureau of Standards. Its chief feature is the use of electric heating to vapourise the pentane and set up the draught through the burner, instead of depending on the supply of heat from the flame. It is felt that the question of air circulation is one of primary importance, and it is hoped that many of the variations in this direction previously experienced may be avoided by this new method. The pentane is placed in a closed reservoir beneath the burner, the heat for evaporation being supplied by a coil of wire of known resistance. It is found, however, that the feed by this method is not so steady as that furnished by the gravity flow of the Harcourt lamp, and up to the present this has been a somewhat serious defect; on the other hand, the method of electrical control has proved quite successful in the matter of air circulation.

Effect of High Temperature on the Ultra-Violet Radiation from Mercury Vapour Lamps.

It has previously been noticed that the ultra-violet radiation from mercury vapour lamps working at a high temperature diminishes perceptibly as the lamps age. Some further researches on the subject have recently been communicated to the Académie des Sciences by MM. Courmont and Nogier, and their results are summarized in *La Revue Électrique*.

The effect mentioned above has been verified in its physical, chemical, and biological aspects. Using a Féry spectrograph, the authors found that the continuous spectrum which is obtained at a high temperature was much less intense in a lamp that had been some time in use than in a new lamp, and especially for wave lengths below 0·2536μ. The chemical effect, *i.e.* the colouration of filter-paper moistened with a 20 per cent solution of potassium ferrocyanide, was found to be considerably weaker with old lamps than with new. A similar difference of effect was noticed when the skin of the forearm was exposed to the rays of old and new lamps. MM. Courmont and Nogier suggest that this diminution in ultra-violet radiation may be due to the fact that the inside surface of the quartz tube becomes gradually coated with a greyish deposit, or possibly that the gaseous composition in the centre of the lamp undergoes some change. The chief conclusion from these investigations is that, if it is desired to preserve a constant efficiency of ultra-violet radiation from the mercury vapour lamp, the temperature of the quartz must be kept low, perhaps by some cooling device.

Need for Good Lighting in Factories—More Evidence from the United States.

We notice that at the sixteenth annual meeting of the National Association of Manufacturers held in New York on May 15th–17th of this year an interesting report was presented by the Committee on Ventilation, Heating, and Lighting. This consisted in a summary of some 250 answers to a series of inquiries addressed to different classes of manufacturers in the United States, many of whom expressed their strong belief in the effect of good illumination in improving quality and output of work.

We hope to refer to this report in greater detail shortly.

Standard Specifications for Street Lighting.

(*Continued from p.* 410.)

READERS will recall that in our July number we published a summary of the replies to a series of inquiries on 'Standard Specifications for Street-lighting,' which were circulated previous to the meeting of the joint committee on the subject appointed in this country. Subsequently some additional replies have been received, and for the convenience of readers we repeat here the list of queries in question:—

RE FRAMING STANDARD SPECIFICATION FOR STREET LIGHTING.

1. Ought the specification to contain a statement of: (*a*) The electrical energy or gas to be consumed; or (*b*) the amount of light provided; or (*c*) both energy or gas consumed and amount of light?

2. Should the amount of light supplied be specified in terms of (*a*) The provision of a certain actual minimum illumination in the street; or (*b*) the provision of lamps of a certified candle-power?

3. If illumination is to be measured, should this measurement be carried out (*a*) in a horizontal plane at a stated height above the ground; or (*b*) in a vertical plane; or (*c*) in some other inclined plane such as 45 degrees? (*d*) Should both the mean and the minimum street illumination be measured and specified?

4. If candle-power is to be tested in the street should (*a*) the mean spherical or mean hemispherical c.-p., or (*b*) the c.-p. in several specified directions be tested?

5. Should the contract demand (*a*) actual measurements in the streets or (*b*) only laboratory tests of the competing lamps previous to the acceptance of a tender, or (*c*) preliminary laboratory tests supplemented by periodical tests of the actual lighting conditions when the lamp is in position?

6. Should any test of the constancy of the candle-power of the lamps be prescribed?

7. Do you advocate the introduction of any stipulation regarding the efficient shading of lamps, height above ground, &c., with a view to the avoidance of glare, such as is recognized to be dangerous and inconvenient to traffic and pedestrians?

8. Should any specific colour of the light be prescribed? If so, how should this be tested?

9. What other clauses would you suggest being inserted?

Additional Replies Received.

Dr. Hugo Krüss (HAMBURG):—

1. Under all circumstances it is of interest and great importance to determine the energy used (electric current or gas consumption), and also the amount of light produced thereby.

2. As a measure of the light, the determination of candle-power does not suffice; the resulting mean illumination should be investigated and not the minimum only.

3. No general rule can be laid down as to whether horizontal or vertical illumination should be measured. In the case of illuminants distributed over extensive flat areas, squares, &c., measurements should be made in a horizontal plane; but in the case of streets provided with lamps arranged in a line the measurements in a vertical plane are preferable. Besides the mean illumination, the maximum and minimum should be determined as a measure of the uniformity.

4. In the determination of intensity mean spherical and mean hemispherical candle-power are not sufficient. The polar curve of light distribution should also be obtained.

5. Measurements carried out in the laboratory are not enough, and should be supplemented by determinations of the illumination in the street.

6. Complete constancy on the part of many lamps (*e.g.* arc lamps) cannot be secured. It should, however, be prescribed that the light should not vary by more than a certain percentage (say about 20 per cent).

7. Recommendations are desirable, but must be adapted to the variety of lamp.

8. As regards colour, an approximation to the quality of light yielded by a white cloudy sky should be aimed at.

By the kindness of **Prof. H. Strache** the list of queries has now been submitted to the **Verein von Gas und Wasserfachmänner** in Austria-Hungary, and the Photometric Committee of the Verein has had the matter under consideration.

We have now received the following valued expression of the views of the Verein on the various points raised :—

1. The Committee is of opinion that in the case of contracts only the candle-power of the lamps to be used should be specified. It should be left to the contracting party to select the most efficient form of burner to furnish the required light.

But when the critical comparison of existing examples of street lighting is in question, the consumption of gas or electricity of the lamps should also be stated.

2. In the case of a contract it would not be practicable to specify the minimum illumination in the street, and it is greatly preferable to require only a certain candle-power as directed in 1. It would be a very tedious process to determine the minimum illumination in all parts of a street beforehand. The securing of a serviceable and uniform illumination is the concern of the local authorities, whose duty it would be to decide upon the number and spacing of the street lamps, and to stipulate how they should be arranged in the contract.

But, again, in the examination and testing of existing installations the determination of illumination is exceedingly important. Not only the mean horizontal illumination, but also the maximum, mean, and diversity factor should be ascertained.

3. The Committee holds the view that on practical grounds measurements of illumination should be made in a horizontal plane 1·0 or 1·5 metres from the ground. The illumination of a vertical surface varies according to the plane selected, and is thus not adapted for precise definition. It would, however, be desirable to find a convenient method of rapidly determining the least and greatest illumination which such a surface can receive when turned in all directions.

4. The Committee considers that for purposes of street lighting mean lower hemispherical candle-power should be considered, and that this should be specified in contracts. Tests of mean hemispherical candle-power should be made on lamps equipped exactly as they would be in the streets, *i.e.*, with reflectors, diffusing globes, &c. In addition to this quantity the spherical reduction factor and the polar curve of light distribution should be required.

5. As a means of checking compliance with the conditions of the contract, only tests made in the laboratory are satisfactory. For this purpose measurements carried out in the streets are too unreliable. The same applies to tests of the diminution of candle-power in course of time, which should also be carried out in the laboratory.

On the other hand, as far as the judgment of street illumination in general is concerned, periodical tests of the candle-power and illumination in the streets may be carried out with advantage.

6. In contracts the permissible diminution in light on the part of specified lamps should be prescribed. In the absence of any specific requirement of this kind a maximum diminution of 25 per cent might be allowed.

7. The Committee considers that the height of suspension should be stated separately for each street to be lighted, since the desirable height depends on the breadth of the street, the intensity of the sources selected, and other circumstances. If, under 1, the contract states the intensity of light demanded, but not the nature of the illumination, recommendations regarding the "glare" from the lamps selected are desirable. By "glare" is understood the specific intensity in candles per squ. cm. of the light-giving surfaces of the source. This shall be taken to apply to the projected area of the illuminating surface in the normal direction of view. This applies particularly to electric glow lamps, for which not the actual superficial area of the filament, but the area enclosed within its limits should

be considered. For the eye cannot perceive the actual form of the filament in lamps in the street.

The permissible height of lamps must be judged according to the local circumstances, but the impression of glare depends to a great extent on the height of suspension. For street lighting it can be assumed in general that a brilliancy of 100 H.K. per sq. cm. is permissible. If the intrinsic brilliancy exceeds this value (as, for example, in the case of the electric arc) some method of diffusing the light, such as the use of opal glass globes, is desirable.

8. A source of light approaches natural conditions most closely when the colour of its light is as nearly as possible pure white. Artificial light can, in general, be regarded as a mixture of white light with light of some other colour. In a light of given composition the percentage of white can be determined by spectro-photometric means, and minimum permissible value of this percentage could be agreed upon. Convenient methods of determining the percentage have still to be worked out. In order to form a judgment of the qualities of a given street lamp in this respect, the distribution of light in the spectrum must be determined.

Forthcoming Course of Lectures on Illuminating Engineering.

SOME time ago we referred to the probability of special courses of lectures on illuminating engineering being arranged at various colleges and institutions in London during the coming winter.

We have now much pleasure in announcing that a course of 12 lectures has already been arranged to take place at **The Polytechnic, Regent Street, London,** under the supervision of MR. LEON GASTER (Editor of *The Illuminating Engineer*). The different subjects will be dealt with by specialists and the dates and lecturers will be as follows :—

TUESDAY, Oct. 31st, 1911, Electric Lighting, by PROF. J. T. MORRIS, M.I.E.E.
„ Nov. 7th „ „ „ „ „
„ Nov. 14th „ Gas Lighting, by MR. J. G. CLARK.
„ Nov. 21st „ „ „
„ Nov. 28th „ Oil, Petrol Air Gas, Acetylene, &c., by MR. E. SCOTT SNELL.
„ Dec. 5th „ Illumination and the Eye, by DR. W. J. ETTLES, M.D., F.R.C.S.E., &c.

THURSDAY, Jan. 11th, 1912, The Measurement of Light, by MR. J. S. DOW, B.Sc., A.C.G.I.
„ Jan. 18th „ Illumination and its Measurement „ „
„ Jan. 25th „ Shades and Reflectors „ „ „
„ Feb. 1st „ Daylight and Artificial Lighting „ „ „
„ Feb. 8th „ The Colour of Artificial Illuminants „ „
„ Feb. 15th „ Practical Lighting Prob'ems „ „ „

All the lectures will take place at **7.30 p.m.,** and will be open to outsiders at a fee of 12*s.* 6*d.* for the entire course and 2*s.* for single lectures.

They will be illustrated by lantern slides and demonstrations, and should prove of interest to many readers of this journal and members of the Illuminating Engineering Society. Further particulars, including syllabus, will be obtainable shortly from The Polytechnic, Regent Street, or from Mr. Leon Gaster, 32, Victoria Street, London, S.W.

The International Photometric Commission.*

(Proceedings at Third Meeting held in Zurich, July, 1911.)

READERS will recall that two previous meetings of the International Photometric Commission were held (also at Zürich) in 1903 and 1907. Useful work was done on those occasions. The proceedings at the third meeting, which has just terminated, provide a striking illustration of the development of international treatment of matters connected with photometry and illumination.

On this occasion Mr. Charles Carpenter and Mr. J. W. Helps, who had previously represented this country, were unable to be present, and the Institution of Gas Engineers nominated Dr. H. G. Colman and Mr. W. J. A. Butterfield in their stead. The President was Prof. Th. Vautier of Lyons; among others present were M. Sainte Claire Deville, Engineer of the Experimental Dept. of the Société du Gaz (Paris); M. F. Laporte, Asst. Director of the Laboratoire Central d'Électricité (Paris); Dr. E. Brodhun, Director of the Imperial Reichsanstalt in Charlottenburg (Germany); Prof. H. Drehschmidt, Chief Chemist of the Municipal Gas Works, Tegel (Germany); Prof. Dr. P. Eitner (Karlsruhe); Dr. Prof. H. Strache (Austria); Dr. L. J. Terneden (Holland); Signor M. Böhm (Italy), and M. Weiss (Switzerland).

PAPERS PRESENTED.

A number of important papers were presented, including a communication by Prof. Eitner entitled 'Modern Photometrical Methods employed in Germany'; 'Some Notes on the Connexion between Illuminating Power and Incandescent Illuminating Value of Gas Burners,' by M. Sainte Claire Deville; a communication from Mr. W. J. A. Butterfield, Prof. J. S. Haldane, and Mr. A. P. Trotter on 'Corrections for the Effect of Atmospheric Conditions on Photometric Flame Standards'; notes by Prof. H. Strache on the 'Connexion between Illuminating and Calorific Values of Gases' and on the 'Absolute Unit of Light'; and a communication dealing with a form of spectrophotometer devised by M. Thovert.

ENLARGEMENT OF MEMBERSHIP OF COMMISSION.

Several of these papers are dealt with elsewhere in this number. It may be observed, however, that some of the formal business of the Commission seems to have been of an important nature, and sets a valuable precedent as regards international co-operation on photometry.

This business related to the suggestion that the membership of the Commission should be enlarged so as to render it more completely international and representative of both gas and electrical interests. It was decided, after some discussion, that the number of delegates representing England, France, Germany, and the United States should not exceed six, and that other countries, which at present sent one delegate, should be entitled to send not more than three.

The question of the full representation of electrical engineers on the Commission was also considered. The President explained that subsequent to the meeting in 1907 the Verband deutscher Elektrotechniker had expressed a wish to be represented, and similar requests had been made by other bodies. It was unanimously agreed that in view of the importance of securing joint action on matters of common interest, such as photometric units and processes, electrical engineers should be invited to participate.

It was also suggested that the

* Readers desiring fuller details of the proceedings on this occasion are referred to the complete account published in the *Journal of Gaslighting*, Aug. 1 and 8, 1911.

Commission should undertake the responsibility of advancing funds to cover the expenses of researches of value, and that the technical institutions interested should be invited to make an annual contribution for this purpose.

Modern Photometry in Germany.

In the discussion of the paper by Prof. Eitner some interesting comments were made. It was suggested that an illumination of the photometer screen of between 10 and 30 lux was desirable.

Dr. Strache alluded to the want of some accurate and speedy method of determining the spherical candle-power of gas lamps. The globe photometer was inadmissible, since the air within the globe soon got used up and affected the light, and the Rousseau method was too long. Some discussion also took place as to the height at which measurements of horizontal illumination should be made. It appeared that in Germany electricians commonly made measurements at a height of 1 metre and gas engineers at 1·5 metres. Mr. Butterfield referred to the Committee on which representatives of the Institutions of Gas and Electrical Engineers and the Illuminating Engineering Society were acting, which was deliberating on this point in London. It was also pointed out by those present that in the case of many large sources provided with reflecting surfaces the inverse square law was only very approximately correct, and that in obtaining the polar curve very large mirror surfaces were necessary.

Subsequently there was some discussion on the paper by Mr. Butterfield, Dr. Haldane, and Mr. Trotter, and communications relating to the comparison of calorific and illuminating values of gas were made by M. Sainte Claire Deville and Prof. H. Strache. Ultimately a sub-committee was appointed to consider this last matter in detail.

The International Unit of Light.

After the reading of Prof. Strache's paper on 'The Absolute Unit of Light,' the report of the sub-committee dealing with the relations between the Hefner, Vernon Harcourt, and Carcel lamps was considered and the now well-known relations between the units employed in Great Britain, France, Germany, and the United States (namely, 1 pentane candle=1 bougie décimale=1 American candle=1·11 Hefner unit) was formally approved. It was, however, agreed that the term "international" should not be applied to the unit agreed upon between France, Great Britain, and the United States for the present, and that this word should be reserved for a unit which would also be acceptable to Germany, Austria-Hungary, and Switzerland.

It was pointed out as most desirable that in literature on these subjects a clear distinction should be drawn between the Hefner and the so-called "international" unit, especially as in some countries both varieties of unit are simultaneously in use. Thus M. Terneden said that in Holland both the Hefner kerze and the English candle were used: M. Weiss said that in Switzerland only the Hefner kerze was employed: M. Böhm stated that in Italy both the carcel and the bougie décimale were used by the gas industry, while the electricians used the Hefner kerze. Italy, however, recognized the new "international" candle.

Symbols and Nomenclature.

The Commission then proceeded to discuss the list of symbols prepared by the sub-committee of the American Illuminating Engineering Society, and also the series of definitions framed by Prof. A. Blondel and published in *The Illuminating Engineer*.* Ultimately these were referred to a sub-committee on which MM. Brodhun, Laporte, Kusminsky, Paterson, and Hyde would act. Another sub-committee was named to investigate the question of an Absolute Unit of Light.

Finally it was agreed that the next meeting should take place in three years instead of four.

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* *Illum. Eng.*, Lond., May, 1911.

Corrections for the Effects of Atmospheric Conditions on Photometric Flame Standards.

By W. J. A. Butterfield, F.I.C., J. S. Haldane, M.D., F.R.S., and A. P. Trotter, M.Inst.C.E.

(Abstract of paper read at the International Photometric Commission at Zurich, July, 1911.)

In most researches on the effects of atmospheric conditions on flame standards investigators have been hampered by several circumstances. In general it is impossible to avoid the different factors concerned, such as humidity, barometric pressure, &c., varying simultaneously. Consequently one cannot readily differentiate by experimental means their separate effects, and one can only draw conclusions from the data representing their combined influence. Again, in general the conditions studied only vary between relatively narrow limits in practice so that a long period of observation is necessary in order to wait for exceptional circumstances to arise. In comparatively few cases will extreme variations of one factor such as are of real value for the investigation be met with. The majority of the readings are really of little utility, and the ultimate conclusions will rest chiefly on a comparatively small number of observations, spread over a considerable interval of time

An investigation of this kind may be carried out in a much shorter time, and much more trustworthy results secured, if the observations are made in a room or chamber provided with means by which one set of conditions may be varied at will to any desired degree independently of the others. The authors therefore carried out their series of investigations on the Harcourt Pentane and Hefner lamps in a special steel compression chamber which had been designed primarily for physiological research on diver's disease, mountain sickness, &c., the air within the vessel being compressed or exhausted to any desired extent.

In this chamber the Harcourt lamp was placed, and the great advantage secured that the pressure of the air could be varied within wide limits without its composition or humidity being relatively very materially altered. Arrangements were also made for the testing of the air within the chamber while photometric readings were in progress so that any change that did occur could be allowed for. In subsequent experiments the effect of vitiation of the air was closely studied, the amount of CO_2 present and the proportion of oxygen in the air being determined by the aid of special apparatus devised by Dr. Haldane. The humidity was studied by the Assmann hygrometer. A simple U tube mercury manometer, one limb of which communicated with outside, was used for measuring pressures above normal, and the pressures below normal were read on a standard mercury barometer inside the chamber. The chamber was also provided with electric light and electric heaters and a telephone communicating with outside.

In carrying out the photometric tests the lamp studied was first compared with an Osram 10 volt lamp run from a small voltage battery of accumulators. This low voltage was selected because it permitted the use of a few portable accumulators as a source of current. However, the filament eventually warped somewhat, thus giving rise to an uncertainty of about 2 per cent, and the light did not remain sufficiently constant. In a second series of experiments a Fleming-Ediswan photometric lamp standard, giving 10 candles at 60·05 volts and fed by a larger battery of accumulators, was

used. The current through the lamp was accurately controlled by means of a mirror galvanometer, provided with an appropriate resistance and used as a shunt to a resistance in the main circuit.

The investigations were confined primarily to the Harcourt 10 c.-p. pentane and the Hefner amyl acetate lamps, but some supplementary and less exhaustive investigations were also undertaken on the Argand No. 2 gas burner, a flat flame gas burner, and an English standard spermaceti candle.

Procedure.

The procedure followed in making the testings was first to take photometric readings in the normal (or prevailing) conditions, then to modify the particular atmospheric condition the effect of variations in which it was desired to study, and to take further readings. After several modifications of the same atmospheric condition had been made and readings taken, the original or normal conditions were whenever possible reverted to, and final readings taken therein as a check on the initial readings. In the earliest sets of observations, the readings thus obtained were corrected to normal in respect of variations in atmospheric conditions, other than those intentionally introduced, by applying Liebenthal's or Paterson's formulæ, if available, or, otherwise, presumptive formulæ. The readings thus corrected were plotted on squared paper; and from the curve obtained therefrom the correction applicable to variations from the normal of the atmospheric condition which had been intentionally varied in the set of observations was deduced. This correction was applied in respect of the accidental variations in that atmospheric condition in subsequent sets of observations in which other atmospheric conditions were intentionally varied. By pursuing this procedure through a number of sets of observations in which first one and then another atmospheric condition was intentionally varied, the corrections applicable in each were gradually deduced with greater and greater freedom from uncertainty. Finally, the results of the whole of the sets of observations were re-calculated with the aid of the corrections so deduced, and the figures thus obtained were re-plotted, and any discrepancies thereby disclosed were examined. This procedure involved much tedious re-calculating of the results of the authors' observations, but it led ultimately to corrections being deduced, all of which were independent of the work or formulæ of other observers.

Corrections for Variations of Atmospheric Pressure.

The experiments made to determine the corrections for variations of atmospheric pressure were all carried out in the steel compression chamber already described. The range of variation of pressure for the observations was from about 450 to 1000 mm. (or from about 17¾ to 39½ in.). The results of the observations were ultimately corrected for the variations in the proportions of aqueous vapour and of carbon dioxide in the air (according to the formulæ referred to later), and the corrected figures thus obtained have been plotted and give the curves shown in Fig. 1. The curves show that the relation between atmospheric pressure and the yield of light is not constant or expressed by a straight line. The

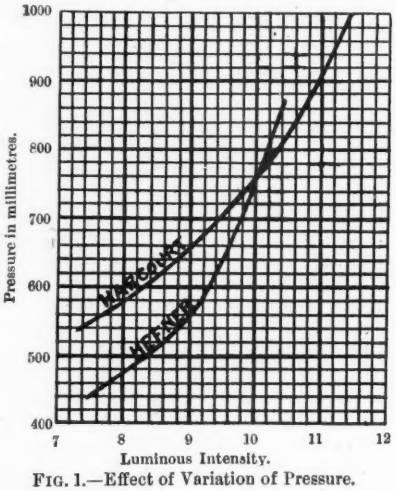


Fig. 1.—Effect of Variation of Pressure.

falling off in the light with reduction of pressure is much greater at the lower than at the higher pressures.

Harcourt Lamp.

The curve for the Harcourt lamp (see Fig. 2) is, however, nearly a straight line for the range of 700 to 850 mm., and shows that within these limits the light increases or decreases by 1 per cent, with an increase or decrease respectively in pressure of 12·5 mm., or that a variation of 10 mm. in pressure is attended by a variation in the same sense of 0·8 per cent in the light afforded by the lamp. These figures agree exactly with the correction deduced by C. C. Paterson (*Journ. Proc. Inst. of Elect. Engineers*, 1907, xxxviii., p. 280), which may therefore be accepted as

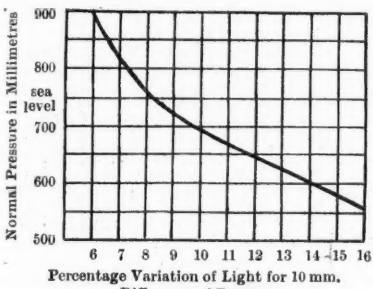


Fig. 2.—Curve of Correction Factor.

correct for variations of pressure at about the neighbourhood of normal.

Hefner Lamp.

The curve for the Hefner lamp is likewise nearly a straight line for the range of 700 to 850 mm., and shows that within these limits the light increases or decreases by 1 per cent, with an increase or decrease respectively in pressure of 25 mm., or that a variation of 10 mm. in pressure is attended by a variation in the same sense of 0·4 per cent in the light afforded by the lamp. These figures differ from the correction deduced by Liebenthal from observations of the variation of the light of the Hefner lamp, caused by the natural fluctuations of the barometer between 735 and 775 mm. Liebenthal has adopted a formula according to which a variation of 10 mm. in pressure is attended by a variation of only 0·1 per cent in the light. (*Zeits. für Instrumentenkunde*, 1895, xv. 157, and *Praktische Photometrie*, p. 121.) Paterson mentions that he found for 10 mm. variation in pressure 0·2 per cent variation in the light. The authors have therefore found that, about the neighbourhood of normal, variation of pressure has only half the effect on the light of the Hefner lamp which it has on that of the Harcourt; but, on the other hand, that it has for the Hefner lamp four times the effect shown by Liebenthal's formula, which has been very generally accepted. The facts that the effect of small barometric changes, such as Liebenthal had available, is small compared with the effect of the unavoidable changes in the proportions of aqueous vapour and carbon dioxide in the air, and that the proportion of the latter was not ascertained by Liebenthal, indicate that his formula for the correction to be applied to the Hefner lamp for variations of barometric height does not rest on acceptable data. The authors ascertained the proportions both of aqueous vapour and carbon dioxide in the air during the observations, and applied corrections to eliminate their effects, while the greater range of barometric change which they had at their disposal reduced the effect of unavoidable errors of observation on the final result. For these reasons, they believe that their figure of 0·4 per cent should now be accepted in preference to Liebenthal's 0·1 per cent for the effect on the light of the Hefner lamp of a change of 10 mm. in barometric pressure in the neighbourhood of 760 mm.

Corrections for Variations in Atmospheric Humidity.

The experiments made to determine the effect of variations in the humidity of the air on the light afforded by flames were carried out partly in the steel chamber already described and partly in a small room at the Electrical Standards Laboratory of the Board of Trade at No. 8, Richmond Terrace, Whitehall, London. This room was 4·03 metres

(13 ft. 2¾ in.) long, 1·975 metres (6 ft. 5¾ in.) wide, and 2·45 metres (8 ft. 0¼ in.) high. The proportion of aqueous vapour in the air was increased as required by passing steam into the chamber or room from a small boiler placed outside it. A large range in the proportion of aqueous vapour in the air was secured by choosing dry, cold days, on which observations of the light of the lamps when the humidity was low could be made. The chamber or room having been heated by electric heaters, the air was then nearly saturated with steam at the high temperature. The range of humidity thus secured was from about 1 per cent to over 4 per cent by volume of aqueous vapour in the air. (Sets of observations on the Harcourt lamp showed that a change in the temperature *per se* of the air from 8° C. to over 20° C. had no definite effect on the light afforded.) The results showed that the light of both the Harcourt and Hefner lamps decreases by 1 per cent for an increase of 0·16 per cent in the aqueous vapour in the air or that an increase of 1 per cent in the aqueous vapour in the air is attended by a decrease of 6·25 per cent in the light of the lamps. Liebenthal found 5·5 per cent for both lamps (*Zeits. für Instrumentenkunde*, 1895, xv., p. 157, and *Praktische Photometrie*, pp. 118 and 128), while Paterson has found 6·6 per cent for the Harcourt and 6·0 per cent for the Hefner lamp (*Journ. Proc. Elect. Engineers*, 1907, xxxviii., pp. 276, 277) as the decrease in the light caused by 1 per cent increase in the aqueous vapour in the air.

Corrections for Vitiation of the Atmosphere by Combustion.

Experiments made to determine the effect of different degrees of vitiation of the atmosphere on the light afforded by flames were made on air vitiated, partially by breathing and partially by the combustion of pentane or illuminating gas. The ratio of carbon-dioxide produced to oxygen consumed differs according to the composition of the fuel consumed, and the composition of vitiated air will therefore differ according as the vitiation arises wholly or mainly from breathing, from the combustion of a hydrocarbon body such as pentane, or of the mixture of a number of combustible gases in which hydrogen predominates, which constitutes ordinary town-illuminating gas. In the experiments made by the authors, the proportions of both carbon dioxide and oxygen in the vitiated air were determined by analysis, and the somewhat complex results obtained will be dealt with more fully in a subsequent communication. But taking the proportion of carbon dioxide in the air as the sole measure of vitiation caused partially by breathing, but mainly by combustion of paraffin hydrocarbons or town gas, it was found that 1 per cent decrease in the light of the Harcourt lamp was caused when approximately 0·035 per cent of carbon dioxide was present in the air, and in the light of the Hefner lamp with 0·045 per cent. Or the presence of 0·01 per cent of carbon dioxide in the air was attended by a reduction of 0·29 per cent in the light of the Harcourt, or of 0·22 per cent in the light of the Hefner lamp. In the experiments on which these figures for the Harcourt lamp are based, the proportion of carbon dioxide in the air ranged from 0·09 per cent to 2·54 per cent, and of oxygen from 20·80 per cent to 17·40 per cent. With 2·54 per cent of carbon dioxide and 17·40 per cent of oxygen, the flame of the Harcourt lamp was blue and practically non-illuminating. The diminution in light is fairly uniformly proportional to the increase in the amount of carbon dioxide up to about 2 per cent of the latter—*i.e.*, the curve given by the figures is nearly a straight line to that point.

General Formulæ for Corrections.

The corrections found for the Harcourt and Hefner lamps may be applied thus :—

Let A = the accepted normal percentage of aqueous vapour in the air.
,, C = the accepted normal percentage of carbon dioxide in the air.
,, P = the accepted normal pressure of the air in millimetres.

Let a=the prevailing percentage of aqueous vapour in the air when the lamp is in use.
„ c=the prevailing percentage of carbon dioxide in the air when the lamp is in use.
„ p=the prevailing pressure of the air when the lamp is in use,
then the actual light (I′) of the lamp at the time, expressed in terms of its light (I) in normal conditions, will be found with sufficient accuracy for all practical purposes from the equations :

For the Harcourt Lamp :—

$$I' = \frac{100 - \left(\frac{a-A}{0{\cdot}16} + \frac{c-C}{0{\cdot}035} - \frac{p-P}{12{\cdot}5}\right)}{100} I$$

For the Hefner Lamp :—

$$I' = \frac{100 - \left(\frac{a-A}{0{\cdot}16} + \frac{c-C}{0{\cdot}045} - \frac{p-P}{25{\cdot}0}\right)}{100} I$$

Effect of Variations in the Atmospheric Conditions on the Light of Gas and Candle Flames.

The results obtained in the observations made on the flames of the No. 2 "Metropolitan" argand, and the Bray $\frac{G}{L}$ 5ft. $\frac{15}{10}$" slit flat-flame gas-burners, when consuming the gas supplied in Chelsea and Westminster by the Gas Light and Coke Company, and on the flame of the English parliamentary standard spermaceti candle, must not be accepted as so trustworthy as those given for the Harcourt and Hefner lamps because they are based on fewer observations. These results are therefore given with reservation in the following tabular statement :—

	One p.c. decrease of light is caused approximately by the following changes from normal.		
	Pressure.	Aqueous Vapour	Vitiation expressed by p.c. CO_2.
No. 2 Metropolitan Argand Gas ..	— 25 mm.	+ 0·20 p.c.	+ 0·03 p.c.
Flat-flame Gas ..	— 5 mm.	+ 0·11 „	+ 0·035 „
Spermaceti Candle	— 20 mm.	+ 0·50 „	+ 0·04 „

These results indicate that small variations in the atmospheric conditions of a gas-testing room will not appreciably affect the results of photometric comparisons in which the Harcourt or Hefner lamp is used as the standard of light, and that these standards will give as accurate results as are anyhow practically obtainable in determinations of the illuminating power of gas if they are used in all ordinary circumstances without correction for any divergence from normal atmospheric conditions. In other circumstances, however, as in the testing of electric lamps by a flame standard, corrections are called for.

A Suggestion for the Absolute Standard of Light.

Dr. Strache made a suggestion at the meeting of the International Photometric Commission, regarding a possible method of defining an absolute standard of light.

The nature of the radiation from a black body at a given temperature, and the distribution of light throughout the spectrum yielded thereby, has been accurately determined. Lummer has studied this in detail and constructed a curve showing the relative sensitiveness of the eye to light of different wave lengths.*

If the total radiation from an incandescent body of this kind were received on a thermocouple attached to a galvanometer one would get a deflection proportion to the entire energy, visible and non-visible. It is therefore suggested that the curve of radiation might be cut down so as to be identical with Lummer's curve and thus furnish only visible light, the value of the energy at each point in the spectrum being proportional to its effect on the eye. In order to do this all that is required is to produce the spectrum of the body, to insert a diaphragm cutting off the light at each point in the required proportion, and then to reassemble the spectrum by means of a cylindrical lens.

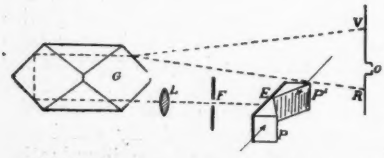
By this means the illuminating value may be expressed in terms of radiated

* Such a curve has also been determined by P. G. Nutting. See *Illum. Eng.*, Lond., vol. iv., Aug., 1911, p. 456.

energy. It should, however, be noted that the curve showing the sensitiveness of the eye will necessarily vary with different individuals; it is therefore desirable that a mean result, representing the results obtained with a large number of subjects, and characteristic of the normal eye, should be found.

A Technical Form of Spectro-Photometer.

A SIMPLE arrangement by which an ordinary photometer of the comparison type can be used to measure relative intensities in the different colours of the spectrum was described by J. Thovert at the recent meeting of the International Photometric Commission.



The apparatus shown in the accompanying sketch is arranged as follows: The prisms P and P_1 reflect the light from the two sources to be compared on to the photometer screen E. Between this screen and the eye-piece are placed a slot F, an objective L, and a pentahedric prism G. The image of the slot F, in which the two illuminations are seen side by side, is dispersed by its passage through the prism so that it is spread over the whole width VR. The eye-piece O can be shifted through the whole range of colour from V to R, and any particular colour can be measured according to its position. The field is observed as two adjacent zones, the brightness of which can be made equal by moving the photometer between the sources of light in the usual way.

It is pointed out that owing to the low values of illumination obtained, it becomes difficult to make observations with wave-lengths of less than $0{\cdot}50\mu$.

The simplicity of the arrangement and its adaptability to the ordinary photometer bench should make this a useful addition to practical photometric apparatus. It is also suggested that a still simpler form—in which the spectrum is decomposed into three principal zones only, red, green, and blue—might be constructed, but this would not be applicable to any but continuous spectrums.

New Method of Adjusting the Hefner Flame.

THE question of the setting of the flame tip of the Hefner lamp received some attention at the recent meeting of the International Photometric Commission. Prof. H. Strache described a thermo-electric method by which, it was claimed, this adjustment could be made with extreme nicety. A thermo-electric couple was fixed in position 5 millimetres above the height of the flame, and connected to a mirror galvanometer. There is then a certain deflection corresponding with the correct position of flame, which must be accurately maintained. If the flame is allowed to sink or is blown to one side the reading of the galvanometer immediately fails.

It is also possible to arrange for an electro-magnetic relay to give an audible signal if the reading deviates by more than a certain amount from the true value, thus warning the observer that the conditions of the flame are abnormal, and leading him to pause in his readings.

Street Lighting by Gas on the Continent.

(Communicated.)

THE high-pressure gas lighting of many of the streets of Berlin has often been the subject of comment. A correspondent now sends us some interesting particulars regarding the recent installation of "Pharos" high-pressure air lamps in that city.

The development of street lighting by gas in Berlin has been phenomenally rapid. It is stated that in the year 1905 only 4½ miles of public streets were lighted by high-pressure gas lamps. But during the years 1906–1911 there was an increase of approximately 30 miles of streets so lighted, and projects involving the lighting of an additional 40 miles of streets are now under consideration. The City Authorities in Berlin have ordered 505 "Pharos" (high-pressure air) lamps from the Deutsche Gasglühlicht Aktiengesellschaft (Auergesellschaft) and 250 Grätzin (high-pressure gas) lamps from the firm of Ehrich and Grätz.

It will be seen, therefore, that both high-pressure air and high-pressure gas are making headway. The former method, which is not so usual for public lighting in this country, seems now to be widely employed in Germany, notably in Stuttgart, where the method of suspending lamps over the centre of the street was first successfully adopted.

In passing, it is interesting to notice that the development of street gas-lighting in Berlin is not attributed solely to the fact that the city owns the gas-works and not the electrical supply. Naturally this factor has an influence. But it is pointed out that although the municipality do not own the electrical supply they *are* financially interested in it, and, indeed, draw a substantial

FIG. 1.—High-pressure Gas Lighting in Berlin. The building on the left is the Imperial Theatre.

revenue from this source. Naturally, therefore, they must desire to see both systems of lighting flourish in their respective fields.

Fig. 1 is a typical example of the spread of high-pressure gaslighting in Berlin. Fig. 2 shows the application of high-pressure gas indirect lighting in a drawing office. It has also been claimed that the high-pressure air system is especially convenient for shops; no special meters are required, and the existing piping can be utilized by merely leading in high-pressure air from the public supply outside.

FIG. 2.—Indirect Lighting by High-pressure Gas in a Drawing Office.

The remaining two illustrations refer to the lighting of Stuttgart. A recent article by the engineer, Mr. F. Göhrum, contained some interesting particulars of the development of public lighting in this city (where, by the way, the municipality owns both the gas and electric supply).

In 1902 it was decided that the public lighting required improvement, and some Lucas lamps were installed with good effect. But this step had whetted the public appetite for illumination, and in 1906 some further experiments were decided upon. One half of the Königstrasse was equipped with seven high-pressure lights, which were suspended on wires spanning the roadway in a similar manner to the electric arc-lamps used in the remainder of the street. As a result of these experiments it was eventually determined that certain streets should be electrically lighted, and that others should in future be lighted by gas and the high-pressure system. By 1909

a number of streets had been so converted. The new method of arranging the gas lamps on wires spanning the streets, and providing means for their being removed to the side of the street and lowered to receive occasional attention, naturally required some study. Eventually a system of jointed piping was adopted, and this has been found the best method in other towns. It was also decided to adopt the high-pressure air system.

There was very little to choose between high-pressure gas and high-pressure air as regards economy, but there were several local factors which favoured the latter. One of these was the popular prejudice against high-pressure gas based on the fear of the results of leakage. This, it is explained, had no sound technical basis, and the decision was merely a concession to a strong, even if unreasonable popular impression. There were, moreover, advantages to be derived from placating the public in this matter, since it was often possible to arrange for a local air-compressor to be placed in the basement of a school or public building, or even a private dwelling; this was a privilege which would only have been obtained with some difficulty in the case of high-pressure gas.

The double tube which the high-pressure air system necessitates is really no objection in this case, but rather an advantage. From the æsthetic standpoint it is preferable, and it also affords a valuable support against exceptional wind-pressure. It is stated that during a recent storm of exceptional severity several freely suspended electric arc lamps were put out of action, but the more rigidly supported gas lamps were not materially affected.

FIG. 3.—The Schlosstrasse in Stuttgart, illuminated by Pharos High-pressure Air Gas-lamps slung over the Roadway.

The lamps are in general hung at a height of 7–7·5 metres and 35–38 metres apart. The maximum intensity is received at an angle of 10 degrees to the horizontal; this is considered excellent for street lighting.

Experiments are now to be conducted comparing 1,000 c.-p. metallic filament electric lamps with low-pressure gas lamps of a similar value for side street lighting. It is also proposed, in order that the change in the bril-

liancy of the main streets and adjacent smaller streets leading out of them may not be too sudden to grade the lighting of the latter. This will be done by using 1,500 candle-power lamps in the parts nearest the main thoroughfare, 1,000 candle-power lamps somewhat further away, and ultimately 600 candle-power lamps in the most remote portions.

FIG. 4.—Showing Pharos High-pressure Air Gas Lamps in a Street in Stuttgart.

A Heterochromatic Photometer.

A MODIFICATION of the Lummer-Brodhun photometer was recently described by Mr. H. P. Gage in a paper before the American Physical Society. In place of the usual cubical prism there was substituted a piece of ordinary looking-glass in which part of the silver was scratched off, not, however, in large patches, but in the form of small scratches. It was found that these scratches could be made to disappear with differently coloured lights, when with large areas, a sharp match could never be made. Fairly sharp settings could be obtained with this arrangement for such differently coloured illuminants as daylight, acetylene, the flame arc, and the Hefner lamp, but in comparing directly contrasted lights, such as red with green, the results were not so satisfactory, except at very low intensities.

Forthcoming Convention of the Illuminating Engineering Society (U.S.A.) in Chicago.

THE fifth annual Convention of the Illuminating Engineering Society (U.S.A.) will be held in Chicago in September, from 25th to 27th. An interesting technical programme is being arranged, a special feature being visits to local lighting installations.

The Annual Congress of the Royal Sanitary Institute.

THE Twenty-sixth Congress of the Royal Sanitary Institute was opened at Belfast on Monday, July 24th, a luncheon being arranged in the City Hall, presided over by the Lord Mayor of Belfast, supported by the Earl of Aberdeen and a number of distinguished members of the architectural and sanitary professions. On this occasion the Health Exhibition in the Ulster Hall was opened, a feature of the exhibition being the display of town-planning models and photographs, showing the latest types of garden villages, &c. In the evening the Presidential Address was delivered by Lord Dunleath, who laid stress on the great advances made in sanitary science in towns and cities during the last fifty years.

There were, as usual, a large number of papers, covering a very wide ground, presented in the different sections. A special lecture was delivered by Dr. Louis C. Parkes on 'The Prevention of Tuberculosis.' There were also several communications dealing specifically with lighting matters, notably the papers by Mr. J. Darch and Mr. W. H. Webb on the subjects of Hospital Lighting and School Classrooms respectively. Special reference is made to these two communications on pp. 520-527. It is very gratifying to observe the definite and prominent attention paid to illumination at this Congress—a precedent which, it may be hoped, will be followed on other occasions.

The Illuminating Engineering Society had appointed four delegates, namely, Prof. Silvanus P. Thompson (President), Mr. L. Gaster (Hon. Sec.), Mr. J. Eck, and Mr. J. Darch, to participate in the Congress. Prof. Thompson and Mr. Eck, however, found themselves unavoidably prevented from being present, and the Society was therefore represented by Mr. Gaster and Mr. Darch.

HOSPITAL LIGHTING.

The paper by Mr. Darch on the subject of hospital lighting will be found on p. 521. In the discussion on the paper the speakers all expressed their appreciation of the importance of good illumination in hospitals, to which insufficient attention was often paid.

Mr. L. Gaster, who was invited to open the discussion, expressed his pleasure in being present as a representative of the Illuminating Engineering Society, and referred to the unavoidable absence of the President, Prof. Thompson, and Mr. J. Eck, as mentioned above. It had therefore been left to Mr. Darch and himself to represent the Society, and he wished to compliment Mr. Darch on the interesting paper he had brought before the Congress.

This paper should serve to bring home the fact that the hygienic aspects of lighting, and the best arrangement of lights, quite apart from the question of cost, had now to be considered by architects and sanitary engineers. It was a sign of the times that illumination should receive such prominent notice at this Congress, and there were many points in connexion with lighting on which the co-operation of architects, engineers, and sanitary experts was needed. A striking illustration of this was provided by the action of the French Government, which had just appointed a joint committee, on which gas and electrical engineers, distinguished oculists, inspectors, &c., were represented, to report upon the hygienic aspects of illumination. This matter was of special interest in connexion with the lighting of factories and workshops, and it was hoped that the Home Office would see their way to appoint a similar committee in this country. Recent reports of H.M. Inspector of Factories had also laid

special stress on the need for good lighting, both in the interests of hygiene and with a view to reducing the number of accidents. He hoped that the influence of the Royal Sanitary Institute would be exerted to impress upon authorities the importance of good illumination from the hygienic aspect, and that it would co-operate with the Illuminating Engineering Society in advocating the formation of a committee similar to that in France.

MR. E. T. HALL, F.R.I.B.A., also agreed that the lighting of operating theatres was often insufficiently studied. Apart from the question of the arrangement of the lights, there were many special points to be considered in the details of the installation; for example, it was considered desirable to keep the wires enclosed in tubes, and to avoid lengths of flex which would tend to accumulate dust and bacteria and might be a source of infection.

Referring to Mr. Darch's remarks on the placing of lights in wards Mr. Hall added that although it was important to avoid discomfort to patients, it must be remembered that lights placed above the beds were mainly intended for the assistance of doctors in enabling them to see the patient, and not necessarily to enable those in bed to read.

One of the most important sections of hospital lighting was certainly the operating theatre, where a strong, even illumination, coming from a number of directions, was needed. In place of the ingenious but somewhat elaborate system referred to by Mr. Darch he had found that tubular lamps, placed in reflectors which screened the filament from the eye and cast concentrated light on the table, were very serviceable.

MAJOR BLACKMAN urged that the lighting of barracks was a matter which demanded urgent attention. At present the illumination was often miserably insufficient, with the result that the soldier was driven from the dark rooms to the brightly lighted gin-palace. This was a question which might well receive more attention from the Government.

SCHOOL LIGHTING.

The paper by Mr. W. H. Webb pointed out some differences in the design of British and Continental schoolrooms. The dimensions were largely a matter of securing adequate daylight illumination. Many authorities advocated that the depth of the room should not exceed one and a half times its height, and Dr. Kerr has recommended that in any case it should not be more than 20 feet.

The question of the tint of wall-papers is an important one, and Mr. Webb suggests that the most suitable colour is a sage green, which is restful to the eyes and does not absorb too much light.

Unilateral left lighting, *i.e.* lighting from the left hand side of the room only, is preferable to bilateral lighting, which gives double shadows, and is condemned by most continental expert authorities. The most general rule determining window-space is that the ratio of the area of windows to floor should not be less than 1 to 5. Mr. Webb also quotes Engelbracht's formula, which has been found of service in Germany.*

In emphasizing the importance of good artificial lighting Mr. Webb referred in complimentary terms to the discussion on school lighting at the recent meeting of the Illuminating Engineering Society, from which he summarized the following definite conclusions :—

1. The rules of left-hand lighting should be observed in that part of the room occupied by the children.

2. Complete absence of glare due to inconveniently placed or imperfectly shaded light is essential.

3. No unscreened unduly bright source of light should be visible in the direct line of sight from the desks or blackboard.

4. An illumination of at least 3 foot-candles is desirable, and in some rooms 4 to 6 foot-candles should be provided.

5. Special attention should be given to blackboard-lighting by lights completely screened from the eyes of the scholars.

* *Illum. Eng., Lond.*, May, 1911, p. 298.

MR. L. GASTER, who spoke subsequently referred to the benefit derived from the discussion of the Illuminating Engineering Society, and mentioned that, as a result, a joint committee, on which other bodies interested were also represented, had been appointed to frame tentative recommendations and collect information on the subject. One important point brought out in the discussion had been the recognition that the earlier figures of Cohn and other authorities for the requisite reading illumination must now be considered too low, and that at least 3 foot-candles should now be considered necessary. The feasibility of maintaining this standard was demonstrated by actual measurements of illumination in many schools in London. It should, however, be borne in mind that much depended upon the nature of the school. Naturally a higher illumination still might be needed in rooms devoted to specially fine work, such as sewing, jewellery work, &c., and in the case of blackboards and demonstration tables.

Mr. Gaster then went on to suggest that tests of the eyes of school children should be supplemented by a study of the illumination, so as to recognize the bad lighting conditions which led to defects of vision. It was also most important that parents, besides scholastic authorities, should be educated to appreciate the importance of good illumination. Children were apt to spoil their eyes by reading at home in dark, insufficiently lighted corners during the evening, and parents should see that this was not done.

In all experiments on these points it was most essential to make use of adequate methods of measuring illumination which was now regarded as quite a simple and practicable process. He suggested that a joint meeting of the Royal Sanitary Institute and the Illuminating Engineering Society, at which the newest forms of instruments for measuring illumination would be exhibited, and their value in studying the hygiene of lighting discussed, might be of considerable value to both bodies.

Other speakers agreed as to the general importance of good lighting, but some difference of opinion was expressed as to whether left unilateral lighting was necessarily better than a distributed system, in which the light came from *all* directions.

The Artificial Lighting of Hospitals.

BY JOHN DARCH, F.S.I.

(Paper read at the Congress of the Royal Sanitary Institute, Belfast, July, 1911.)

IN visiting the principal London and other hospitals I have been keenly struck with the universal want of discrimination in lighting; there is a kind of trade orthodoxy which cherishes certain forms and fittings, and decrees their use often in defiance of common sense. Take, for example, the ubiquitous plain 10-in. opal shade pendant, that does duty but is equally unsatisfactory in ward, kitchen, operating theatre, corridor, and consulting-room. It would be difficult to find a more irrational, inefficient, and indefensible fitting for most of the purposes to which it is applied, while it can hardly lay claim to be a thing of beauty. The shade affords no protection to the eyes of patients or nurses against the sting of the glowing filament, and from the fact that thousands of cardboard "eye-screens" have been sold to patch up this so-called "shade" for the necessary protection of the eyes of the healthy and vigorous in office and shop, it must be obvious that it is unsuited to a hospital. Again, the shade darkens the ceiling, and, by preventing reflection from its large white surface, practically darkens the room.

Another token of orthodoxy is the swan-neck bracket (Fig. 1), which, with its popular form of "shade" that shades nothing, and its bare light, has been described as "nothing less than an instrument of torture." In some hospital wards the brackets have

been mercifully placed lower and closer to the walls.

Light (and in that term radiation, both visible and invisible, must be included), like any other form of power, may become an agent of destruction, or a minister of health and blessing, precisely in accordance with the wisdom shown in its application ; and it is the duty of the professional advisor, be he architect or engineer, to understand all that pertains thereto before he can pretend to satisfactorily invest his buildings with the instruments of such a force.

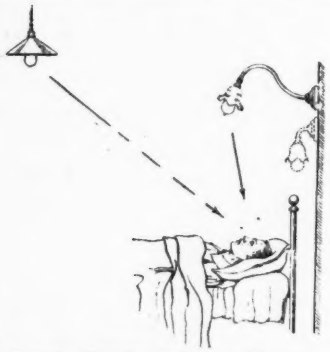


FIG. 1.—Showing various positions of Patient's Light.

There are to be avoided, on the one hand, the evils of glare, and particularly that which, in a ward patient, would enter the lower part of the eye ; the evils of excessive brilliancy, of violent contrasts of light and shade, and of the injurious and troublesome rays of heat and actinism ; there is also to be avoided the risk of eye strain consequent upon insufficient light or upon the effort to see in the face of misplaced lights.

The value of illumination depends not on the amount of light that is shed throughout a room, but on that which is reflected from visible objects. An essential part, therefore, of any scheme of illumination is the colouring of walls and ceilings, the strength of which must be properly balanced with the amount of light available. Dark colours eat up the light and are therefore wasteful. White ceilings, cornices and friezes, not glossy, with pale tinted walls and slightly darker dados, will best serve the hospital and its inmates.

Let us proceed to consider some practical methods of dealing with the subject, and begin with

THE HOSPITAL WARD.

The average ward unit—of, say, 20 beds—should be provided with two kinds of illumination, viz. (1) general, and (2) local.

1. *The General Lighting* need be no more than enough to see clearly about the room, say, 0·5 foot-candles.

No sources of light, nor any illuminated surfaces exceeding 0·1 candle-power per square inch (14 c.p. per square foot) should be exposed to the patients' or nurses' eyes ; whereas the intrinsic brilliancy of the

Gas mantle averages	30	c.p. per sq. inch.
Acetylene flame	40	" "
Electric carbon filament	400	" "
" metallic "	1,000	" "

Direct illumination, therefore, useful enough in the lofty out-patients' hall or elsewhere, is quite unsuited to a hospital ward.

Direct lighting lamps may, however, be used if provided with proper shades, but everything depends upon that word "proper." Glass shades and all transparencies are inadmissible, nor should any partial translucency exceed the above-named limit of brightness, while any shade that is used should effectually screen the eyes without materially darkening the room. Such a shade is shown in Fig. 2, and is a ring of semi-opaque material so adjusted that it will fully illuminate ceilings and walls while protecting the eye in all its normal positions. If bracket lights are used for general lighting, a half-circle shade should be used so as to illuminate the wall. The practical result of all this is a soft all-over illumination which is very pleasing.

High-placed ceiling lights will prove equally successful with carefully calculated shading.

Indirect lighting by means of the inverted electric arc is deservedly gaining favour, but although it would serve well in many parts of a hospital, I could not recommend it for the ward, as the ceiling would be too dazzling for those who have to lie on their backs.

A happy effect may, however, be obtained from indirect lighting, with tungsten or other metallic filament lamps, placed inside a shallow metal bowl, white on the inside. To obtain the best effect they should be hung as low as convenient, nor should the lamp be set too low in the bowl.

Night Lights.—Excepting in the winter, artificial lighting is little needed in the ward, for hospital economy favours very early hours, but some sort of subdued lighting is necessary during the night watch all the year round. With gas or acetylene a small burner, shaded, on a bye pass would do. In electric lighting, several expedients have been adopted, but a 2 c.p. shaded lamp is the most economical. An excellent arrangement is indirect lighting from an 8 c.p. lamp in a small bowl. This is employed, for night purposes only, at Tooting Bec Asylum.

2.—*Local Lighting.—The sisters' and nurses' tables* should each have a well-shaded lamp that is adjustable in height, so that any desired intensity may be obtained. A comfortable illumination for reading is 4 foot-candles, but 10 ft. c. is not too much for some purposes. A good form of shade is a deep cone of dark green opal, with the lamp entirely recessed. A more cheerful form would be one with a rose silk flounce with white lining, deep enough to hide the lamp, and for cleanliness the top should be of white opal glass, and the flounce easily removable.

The Patients' Lights are best placed one at the head of each bed, hidden in a dark green opal shade and somewhat to the left so as not to radiate heat on the patient's head, and to avoid gloss in reading (see Fig. 2): an illumination of four candle-feet should be available. This lamp will be useful for examination and should illuminate the patient's chart. Near this there should be a plug for a hand or standard lamp.

If gas is the lighting medium, a "bijou" inverted mantle similarly shaded would be suitable for both

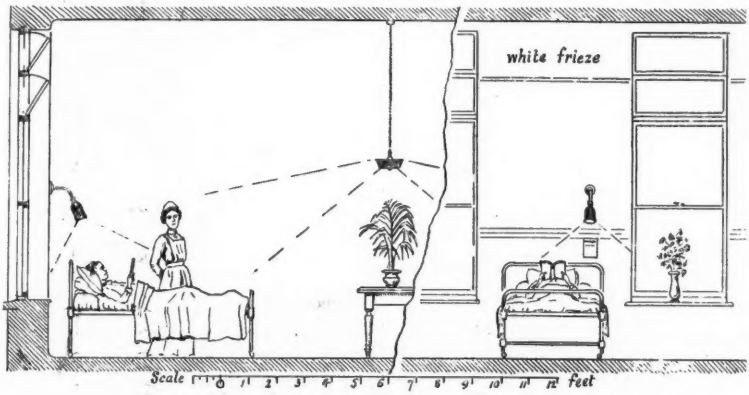


FIG. 2.—Lighting of Hospital Ward (Section and Elevation).

patients and nurses; if acetylene is used a small flame burner is adequate.

Steadiness is an essential condition of good sanitary illumination, for fluctuation and flicker are not only very disturbing, but may amount to permanent injury. This trouble may arise (*a*) from the glow lamp when used on an alternating current whose frequencies are below, say, 35 per second; (*b*) from an arc lamp when the light varies in intensity and colour, due to unsuitable or impure carbons; or when it "pumps," due to defective feed mechanism; (*c*) from the gas mantle, due to an ill-regulated air supply, accumulated condensation in pipes, or the wind from the open windows of the ward; and (*d*) from all

flame burners by the two last-mentioned causes.

Gloss is frequently as troublesome as bare lights, and yet the majority of hospital wards have shiny ceilings. There should be no difficulty in getting a diffusive or dead surface as sanitary as that of the objectionable gloss.

The Operating Theatre.

The operating theatre needs good artificial light and plenty of it, for there is a large proportion of surgical work done after dark. It should have a separate *general* illumination with screened lamps over the sinks and sterilizers. The ceilings and walls should be completely reflective, and are best lined with close-jointed white glazed tiles or opalite, with a little relief in the form of a pale green or grey dado.

The illumination of the operating table is, of course, the leading consideration. The light should approximate to the colour, the perfect diffusion and the high intensity of broad daylight; both the nuisance of overhead heat and the septic risks of dust collection should be avoided, and the fittings and glass employed should be plain, smooth, and easily cleansable.

It is important that the lights should not all be clustered together, forming deep and troublesome shadows, nor be situated directly over the table to worry the surgeon with the shadows of his own head and hands, or that would necessitate the frequent shifting of the table. Yet these are the arrangements most commonly met with.

Every hospital has its own pattern of operating light (scarcely two are alike), while many of them are very curiously contrived. The following may be taken as typical of the more usual arrangements —

1. One or more plain shade pendants of the common type, sometimes with a dust raising counterweight and pulley.
2. A cluster of from two to twenty glow lamps under a large opal shade.
3. Rectangular trough 4 ft. long, with opal sides, full of lamps and sometimes with a sheet of opal glass underneath; this gives an excellent light, but the heat is intolerable.
4. A four- or six-light electrolier, each arm with a separate lamp and opal or aluminium bell shades.

Either of the foregoing may depend from the ceiling or from the end of long swing brackets. Glow lamps should have metallic filaments; tungsten is said to give the whitest light. Gas burners are sometimes attached.

At Charing Cross the drawback of concentration is well met by distributing the light over the long arms of four brackets and round the gallery front.

The London Hospital and that at Ryde are fitted with Marshall's operating light, shown in Fig. 3, consisting of

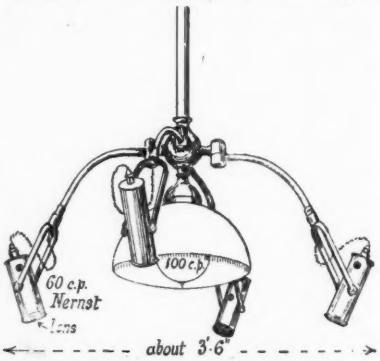


Fig. 3.—Operating-theatre Lamp.

a fixed central 100 c.p. lamp under an opal reflector, with four hinged arms, each with a 60 c.p. Nernst lamp in a condenser tube projecting the light to any desired spot.

Electric Arc Lamps are employed in some continental theatres.

Direct lighting with ordinary arc lamps is out of the question on account of the unavoidable shadows, excepting, perhaps, for general lighting; but where there is a large skylight, a splendid direct illumination may be obtained from white flame arc lamps, which have a remarkably high efficiency, and throw most of their light downwards. Four of these may be suspended over, but not too close to the ceiling light, which should be of clear fluted glass to spread the light. They may be fixed, or may move on rollers worked by cords in the room. Questions of dust and the

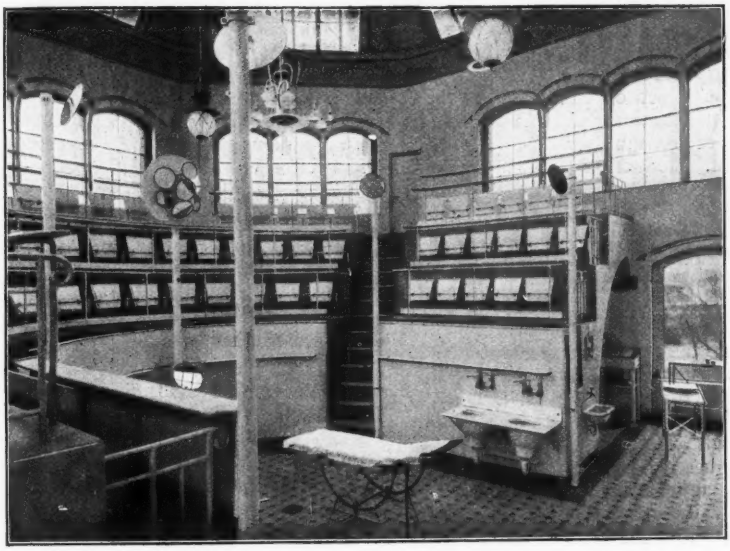


FIG. 4.—Operating Table lighted by the Siedentopf system. General lighting by Arc lamps.

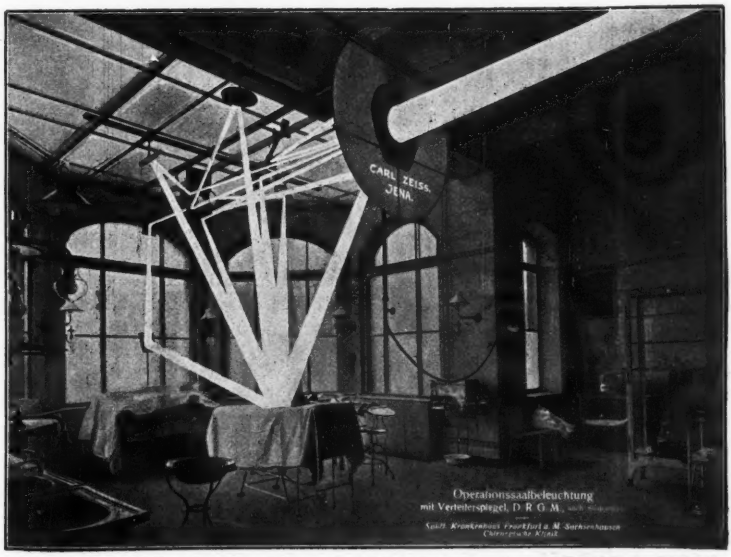


FIG. 5.—Showing the direction of beams in the Siedentopf system of lighting for operating tables.

(We are indebted to the courtesy of the Royal Sanitary Institute for the use of the above illustrations.)

intrusion of lamp trimmers are thus eliminated.

Indirect arc lighting, particularly where there is no skylight, is eminently suitable. Four 10 ampere open arcs, properly placed and reflecting directly against a white ceiling, would give a brilliant illumination with all the advantages of day ight.

Prof. Siedentopf has invented an ingenious arrangement for lighting the operating table by means of isolated beams of light which are not only ample, but entirely avoid the dust question.

There are two forms of it :—

1. The single, in which a 20 ampere projector, or searchlight, is placed outside the theatre, and about 7 ft. 6 in. high, from which a parallel beam of light is directed through a hole to a small mirror, thence to the table, or through a second mirror to the table. This beam is controlled by an iris diaphragm and smoked glass. It is best suited to the gynæcological and throat theatres. It is necessary to have good general lighting.

2. The compound form is more satisfactory (see Figs. 4 and 5). A projector lamp, as before, but of 25 to 30 amps., directs the light through an aperture to a thin metal disc, on which are placed small distributing mirrors which divide the main beam into a number of smaller ones, and which are separately projected to receiving mirrors placed around the room. These mirrors reunite the light on the table in a many-sided form, free from shadows.

Emergency Lights.—Electric fuse wires have a knack of "going" at most inopportune moments, while a breakdown on the part of a supply company is not unknown ; it is therefore essential to have a reserve for such an emergency. The fusing trouble is more common on branch circuits ; one excellent precaution, therefore, will be found in wiring glow lamp fittings from two separate main branches, either of which failing, enough light may be left to work by.

To provide against failures on the main there are two methods :—

1. A gas lamp with an inverted mantle, as at the West London Hospital, which should be lit during operations.

2. An electric accumulator, from which a small emergency lamp should be kept alight during operations, and in connexion with which it should be possible to immediately switch on sufficient light from the accumulator to complete an operation. Separate lamps would be required for this purpose unless it would be convenient to have the voltage of the accumulator equal to that of the circuit.

Some hospitals keep oil lamps ready to hand.

Hand and standard electric lamps of a variety of patterns are to be found in every operating theatre.

The Dispensary.

is usually the worst served of any department. It is, in London, frequently to be found in the basement or in some other part of the building lacking daylight, while the artificial illumination is commonly so inadequate that it sometimes becomes a difficulty and a worry to read the prescriptions. Many of the bottles abide in gloom, while the poison cupboard which, with its small bottles needs a particularly good light, often fares no better. Happily, the busy dispenser acquires habits of caution, and mistakes are rare, but when a dispensary has to make up from anything to 500 bottles of medicine daily, it is surely worth the cost of better lighting to minimize the risk, to say nothing of avoiding injury to the eyes of the dispenser.

A properly shaded light yielding four or five foot-candles is required to each man on the dispensing benches. The shelves should be illuminated with screened lights to facilitate visual acuity, in fact, no bare lights should be visible. Undoubtedly, the inverted arc lamp with a white ceiling would afford the best illumination, while the running cost of it should compare favourably with that of glowlamps.

Where is the dispensary or laboratory that provides facilities for reading the graduated measuring glasses ? Nothing is more productive of eye strain than the effort to decipher any kind of graduated scale, but with the faint lines of a glass measure in the twilight of the average dispensary

held up to a patchwork background of bottles the strain is increased. It would save time and afford comfort if small white screens were fitted up, one in front of each man, adjusted to catch the chief incident rays from a skylight or window at such an angle that they reflected towards the dispenser. The same screen could be used under an artificial light or in a permanently dark situation, or there should be an illuminated panel of either reflected or transmitted light.

The commercial mind has realized that the health of the worker is the wealth of the employer, and that the extra cost of better illumination is repaid a hundredfold in time saved and better work produced. Hospital authorities might do well to look at it in this light, if no other.

I have dealt only with the three characteristic departments of hospital service, and regret that space has failed me to treat of such equally needy subjects as the proper illumination of sight-testing types, the lighting of the consulting room, the out-patients' departments, the corridors, staircases, and general service rooms, but I trust that sufficient has been said to demonstrate the need for reform and the direc tion it should take.

Irving and Stage Lighting.

Mr. Bram Stoker, writing in the May number of *The Nineteenth Century*, gave an interesting historical account of improvements that have taken place in stage lighting, many of which may be attributed directly to the thought and care which Irving always bestowed on the details of his productions.

Many of the devices which had to be resorted to in the early days when gas was the only possible illuminant, are of considerable interest, and serve to show how serviceable electric lighting has been in rendering possible the beautiful lighting effects of the present time.

According to the author, the darkening of the auditorium during the presentation of a play was rarely attempted prior to the days of electricity, and Irving appears to have been the first to appreciate the importance of concentrating attention on the stage and removing the distraction of surroundings by the simple aid of darkness.

In a former article on stage lighting in this journal,* reference was made to the elaborate system of regulating resistances or "dimmers" usually installed in a modern theatre for varying the brightness and the colour of the illumination. It is of interest, therefore, to know that Irving had at first to be satisfied with the somewhat crude plan of drawing strips of silk between the lights and the stage in order to produce gradual changes in the illumination. Changes of colour were obtained by using differently coloured silks, but at that time the colours (generally red, white, and blue) were nearly always used one at a time, and it remained for Irving to realize the possibilities, brought about by the introduction of electricity, of combining and grading coloured lights so as to produce delicate tints and hitherto unknown effects.

An example of his enterprise is seen in the fact that he was the first to apply electricity to the production of sparks when swords crossed in the fight between Faust and Valentine. So much importance was attached to the proper lighting of a scene on the stage that, we are told, Irving used to hold special "lighting" rehearsals, with his full staff of electricians and mechanics in attendance, so that every effect might be studied beforehand and brought to the perfection which he desired.

* *Illum. Eng.*, Lond., vol. i., Aug., 1908, p. 645.

The Lighting of the Horniman Museum.

SOME ADDITIONAL DETAILS.

IT will be recalled that in *The Illuminating Engineer* for June some particulars were given of the lighting of the Horniman Museum. By the courtesy of Mr. Chas. A. Baker, Electrical Engineer to the London County Council, we have now received some additional particulars regarding the most recent developments in the present lighting and the method to be employed in the extension of the building now in course of erection.

The lighting of this Museum was originally connected to the mains of the Crystal Palace and District Electric Supply Company, who supplied at 100 volts continuous current. When this company became merged in the South Metropolitan Electric Light and Power Company it was necessary, in order to continue the use of the inverted arc lamps which affect the greater portion of the artificial lighting, to instal a motor-generator, as the South Metropolitan Company supply an alternating current, two-phase. In order to avoid the disturbance which might ensue in the event of a total extinction of the light owing to failure of the supply, when the building was rewired, the centre arc lamp in each of the two halls, and a sufficiency of incandescent lamps throughout the building—more especially in the corridors and on the staircases—were connected to a special circuit controlled by a two-way switch in the lobby, where an attendant is always on duty when the public are in the building. This switch was fed from the ordinary supply and alternatively from a small secondary battery which is installed in the basement of the Museum.

A new lecture hall and library are now being erected alongside this Museum, and the lighting arrangements that are being installed include a similar emergency system for the library and staircases as obtains in the old Museum.

The new lecture hall will be lighted by nineteen 100 c.-p. metallic filament lamps placed close up to the ceiling and to the girders which run transversely across it. The lamps are placed in rows of four, except the back row, which has three installed, and in such a way that the light is screened from the eyes of the audience by the girders. The height of the room is about 15 ft. and the area some 1,800 sq. feet. The illumination will therefore be ample.

In addition, provision is made for a projector lantern, so that the lectures may be illustrated by slides.

The method adopted in the library calls for no special comment. In addition to a few lamps for general illumination two 25 c.-p. lamps under deep green and white opal shades are placed over each reading table, which measures 3 ft. 6 in. by 7 ft.

Holborn Public Lighting—Joint Tender Accepted.

READERS will recall that an interesting situation was created by the recent co-operation between the Gas Light and Coke Co. and the Metropolitan Electricity Supply Co., which presented a joint tender providing for some of the streets in the borough of Holborn to be lighted by gas and others by electricity. The scheme was referred back by the Holborn Borough Council to the Works Committee for consideration.

At a meeting on July 26th the decision was finally reached to accept the tender, and the striking precedent has therefore been established of a combined scheme of lighting undertaken by the local gas and electric lighting companies. It will be interesting to see how far circumstances lead to the adoption of this policy in other districts.

The Value of Photography in Illuminating Engineering.

By J. S. Dow and V. H. Mackinney.

On March 28th of the present year a paper was read by the authors before the Royal Photographic Society dealing with this subject.* It was pointed out then that photography is a very valuable weapon to the illuminating engineer, since it enables him to preserve a record of the appearance of illuminated interiors, the nature of the lamps and fixtures, the distribution of light, &c.

It may be pointed out that the two subjects of photometry and photography have much in common. Photographers and lighting engineers have in the past frequently carried out independent researches on almost identical lines, and reached very similar conclusions. For example, the average variation of daylight at various periods of the year and during different times of the day was studied by Hurter and Driffield from the photographic standpoint many years ago; similar researches have been carried out by Prof. L. Weber of Kiel, and by Nicholls and Basquin in the United States, who viewed the question from the aspect of one concerned with the lighting of school-rooms.

The taking of photographs by daylight is often of interest to lighting engineers. Photography enables us to preserve a record comparing daylight and artificial illumination under different conditions. But whatever our intentions may be, it is necessary to approach the subject from the standpoint of the lighting engineer, and to consider exactly what are the conditions we wish to record. The taking of photographs by artificial light is often a particularly delicate matter. For scientific reasons it is often essential that there should be no retouching of the negative or print, and the exposure must therefore be judged very accurately. It is also necessary to remember that in such cases one often wishes to aim at reproducing the exact distribution of light and yet to show the nature of the actual sources of light without halation or glare.

Such photographs are specially valuable when presented in conjunction with measurements of illumination. There have been many cases in which photographs have been reproduced in *The Illuminating Engineer* in order to demonstrate special points in certain installations. For example, in the article by Mr. Justus Eck in the August number of the journal, photographs were relied upon to illustrate the nature of the shadows cast by inverted arc lighting, and to compare them with those derived from daylight. The effects shown in the photographs were confirmed by measurements taken with the Holophane Lumeter.

Judgment of Exposure.

One of the chief matters to be noted in taking photographs of this kind is the necessity for judging the exposure correctly for the purpose in view. In the case mentioned above, for example, the whole intention of the photographs would have been lost if the degree of light and shade had been incorrectly represented owing to the exposure being too short or too long; yet, technically speaking, the photograph might have been quite a good one in other respects. The fact is that the variety of tone which one meets with in practice is far greater than it is possible to represent in an actual photograph. The immense possible variations in this respect will

* *Photographic Journal*, April, 1911.

be gathered from the following very approximate table:—

Probably many expert photographers estimate the exposure required mainly

CHART SHOWING THE ENORMOUS VARIATION IN BRIGHTNESS OF DIFFERENT OBJECTS MET WITH IN PHOTOGRAPHY.

Nature of Surface.	Equivalent Surface brightness in Foot-candles. (Very approx.)
Sun at zenith	860,000,000
Electric arclight (crater)	7,600,000
Electric metallic filament	400,000
Incandescent mantle	15,000
White surface, illuminated by direct sunlight in summer	6,000
White sky (average)	2,000
Candle flame	1,000
Dark buildings, tree-trunks, &c., illuminated by diffused daylight	500 to 50
Diffusing shades over artificial sources of light	500 to 50
White objects in brightly lighted shop windows	50 to 10
Page of book illuminated by artificial light (good reading illumination)	5 to 3
Wallpapers and ceilings in artificially lighted interiors	1 to 0·1
Dark portions of churches, deep shadow, &c.	0·5 to zero

Now it is very difficult to secure (in a flat picture) a more violent contrast of light and shade than 30 to 1. This can be verified by placing side by side a suitable dead black surface and a sheet of perfectly clean white blotting paper or celluloid, so that they receive the same illumination, and comparing the surface-brightness in the two cases with the Holophane Lumeter. This range of 30 to 1, in fact, seems to represent about the limit of variation in reflecting power met with in practice.

It will readily be understood, therefore, that in many interiors we meet with contrasts far greater than this, and the question arises which tones are most important to reproduce faithfully? A photographer interested from the artistic standpoint would take a certain view and adjust his exposure and development accordingly. But the lighting engineer would frequently require other quite distinct qualities from the photograph, and might find it necessary to deal with the subject on entirely different lines. It is clear, therefore, that for this work it is desirable to have both a good knowledge of the technicalities of photography and a clear appreciation of the purpose, from the illuminating engineering standpoint, which the photograph is intended to serve.

by the weight of accumulated experience. But however skilful in this respect a photographer may be, he would be more than human if he were not sometimes deceived by the unaided eye, which finds extraordinary difficulty in judging correctly the comparative brightness of different surfaces. It is a surprise to many people, for example, to discover that the brightness of many dark objects illuminated by daylight, such as sooty surfaces of buildings, tree trunks, &c., are, even on a dull day, almost invariably many times as bright as the printed page of a book illuminated by artificial light would usually be. In the daytime our senses seem to be keyed up to a different level.

In this connexion the following experience of the writers may be of interest. One evening when dusk was falling, they were passing through a park and took a few measurements of the brightness of tree-trunks and similar dark objects. Subsequently they entered a tea-shop. The effect was that of stepping from comparative darkness into a brilliantly lighted interior. Yet the actual brightness of the apparently brilliantly illuminated white tablecloth was actually less than that of the dark and almost indistinguishable tree-trunks outside.

To sum up, therefore, it would seem that to photographers of average experience it is exceedingly difficult to judge exposure exactly by the unaided eye.

To overcome this difficulty researches have often been aided by the actinometer, in which the exposure is calculated on the time taken by some sensitive paper to reach a given shade of darkness. This method has the advantage that it allows for the chemical effect of the light, as distinct from its effect on the eye. Naturally, however, its working depends merely on the light received, and does not take account of the lightness or darkness of the object photographed, or of the possibility that it may be in comparative shadow. For this reason it is usual to multiple the estimated exposure by certain constants according to the nature of the subject (*e.g.*, whether clouds, dark trees, light or dark interiors, &c.), and success, therefore, depends to a great extent on the judgment of the observer. Another difficulty is that in relatively dim surroundings an actinometer takes too long to record any visible change; in fact, it is practically of no service for interiors, and this may also be said to be true in the case of artificial illuminants.

The authors, in looking around for some serviceable means of determining exposure in artificially lighted interiors, hit upon the idea of making use of the Holophane Lumeter. This instrument has been described in *The Illuminating Engineer*,* and provides a convenient means of measuring surface-brightness. This is very serviceable for many purposes in photography. It enables the comparative brightness of different objects in the field of view to be rapidly and easily determined, and takes account of their reflective power, distance, &c. It can also be applied to study inaccessible and distant objects.

From the standpoint of the lighting engineer the method is also convenient because photographs of artificially lighted interiors will usually be accompanied by data regarding the distribution of illumination. The instrument may therefore be used both for obtaining information about the lighting installation and the amount of illumination provided, &c., and also in determining the exposure for the photograph. One merely determines the surface-brightness of the most important objects, and, by comparison with previous results, can soon predict with confidence the exposure which appears to be most suitable. This method has been employed for some time and strongly advocated by Mr. T. E. Ritchie of the Union Electric Co., and in the authors' experience has also proved most successful. Quite a number of photographs reproduced in this journal were obtained by this means, and it may be said that, although interiors lighted by many different illuminants have been studied, there has never been an actual failure. In a few cases greater experience has suggested that a slightly modified exposure might have given even better results, but the photograph has invariably served to show what was required.

Naturally one's aptitude increases with experience of the method, but it has the great advantage of providing a complete record on which to rely when meeting new conditions. It may be suggested that a novice who studies the surface-brightness of each subject in a systematic way would make considerably more rapid progress than one who had no such means of comparing his result with the exact conditions of light and shade in the view photographed.

Effects of Colour of Subject or Illuminant.

There is one other point which deserves special attention. It is well recognized that illuminants differ considerably in their actinic value; it is therefore possible, for example, that a room lighted by arc lamps might prove to have a lower average surface-brightness than one lighted by distributed carbon filament glow-lamps, and nevertheless might require a shorter exposure. At an early point in their investigations the

* *Illum. Eng.*, London, Nov., 1910.

authors carried out a series of experiments on a white surface, illuminated in succession to the same brightness by electric carbon filament lamps, tungsten filament lamps, incandescent gaslight, daylight, electric arclight, and mercury vapour lamps, the plates being given the same exposure in each case and developed under identical conditions. The results, which were summarized in the paper before the Royal Photographic Society, clearly showed the desirability of making a correction for the actinic value of the light. Yet with experience there is no difficulty in making a suitable allowance for this factor, and the Holophane Lumeter method has been applied quite successfully to interiors lighted by many different methods, and even in cases in which there was a mixture of daylight and artificial illumination.

The photography of *coloured objects* is a difficult problem, and tests of the exposure by any method, whether based on surface-brightness or on actinometer readings, must be applied with discretion. It is well known, for example, that the ordinary photographic plate judges colours in quite a different manner from the eye, and that red objects tend to come out much darker than they should do. It is therefore sometimes advisable to avail oneself of special methods, such as the use of a Wratten Panchromatic plate with a K_1, K_2, or K_3, or even a red filter, in order to bring out the tones in a more satisfactory manner.

In passing it may be said that the problem of reproducing objects in natural colours is also a fascinating one to the lighting engineer. A photograph, which shows tone well may often suffice, but the ideal result would be a print or transparency, which also supplies a record of the colour. In the case of decorative and spectacular lighting this is particularly desirable. Some experiments have been made in the use of Lumière colour plates. Results have been obtained which were encouraging, and to which reference may be made on a future occasion.

The difficulties in using this method are, however, considerable. It is usually necessary to give from 60 to 80 times the exposure which would be needed for a plate of the ordinary rapid kind, and the plates must be subsequently developed in almost complete darkness. Moreover, the exposure must be very accurately judged, otherwise the colours are distorted; it may be added that, once the photograph is taken, the subsequent development can only be controlled with extreme difficulty. Yet another point to be noted is that the possible range of tone seems to be more limited than in ordinary photography, so that the results of incorrect exposure are more readily apparent. It also appears that the form of screen which answers for daylight work may not prove satisfactory for artificial illuminants. The method would, however, be a valuable aid in recording the appearance of coloured objects illuminated by various illuminants, and it is hoped that these incidental difficulties may be eventually overcome.

Other Uses of the Holophane Lumeter in Photography.

There are a number of other purposes to which this instrument might be put in connection with photography.

By its aid it is very easy to compare the reflecting power of different materials, the opacity of negatives, or the distribution of tone in prints, and the absorption of dark glasses and solutions; it might also be found of service in testing the speed of plates, and in research work of all kinds, with photographic sensitive materials.

It might also prove of service in the hands of the teacher, as it affords a ready means of demonstrating the exact prediction of the exposure necessary and the results of over- and under-exposure.

In making lantern slides and in process work, where a certain illuminant is constantly employed with subjects embracing a wide variety of light and shade, it should prove particularly useful.

Examples of Photographs.

In conclusion a few examples of photographs taken by this means, with particulars of the conditions of illumination, may be of interest.

Naturally in these cases the method employed depends on the uses to which the photograph was to be put. In some instances, one merely wishes to show the general nature of the illumination of the position of the sources, &c., and is not concerned with minute accuracy in the distribution of light and shade; the main object is to secure an attractive picture.

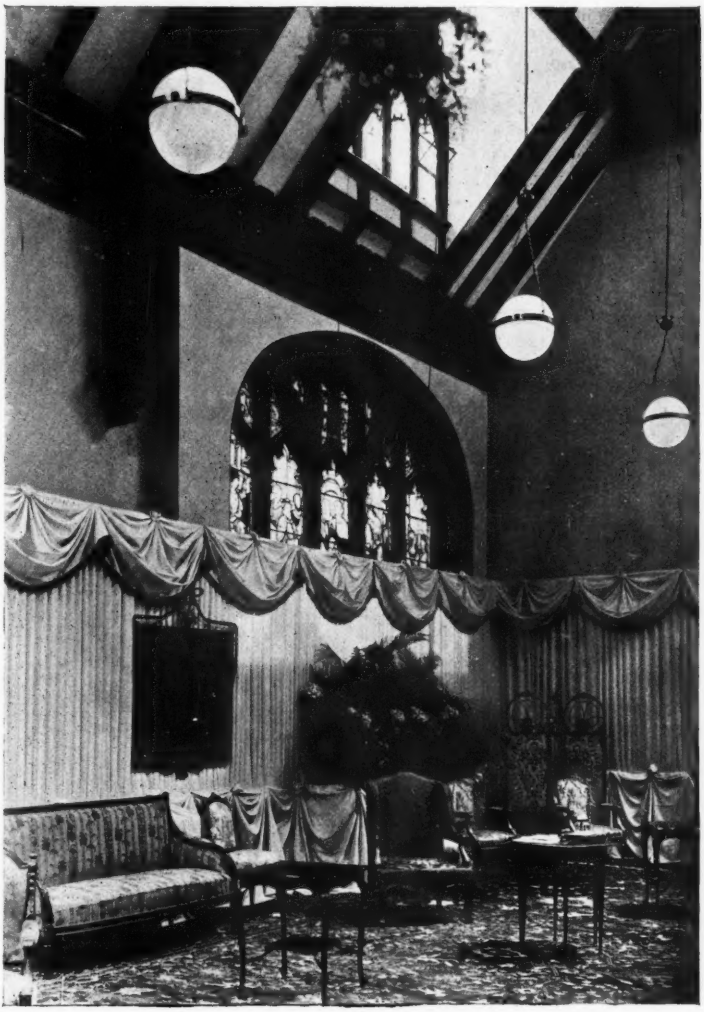


Fig. 1.—One of the retiring rooms used by their Majesties on the occasion of the Coronation Banquet at the Guildhall (London).

In other cases, notably the comparison side by side of the effects of different types of reflectors, &c.,

the correct distribution of light and shade, and the comparative brightness, are *the* vital matters, and other points (such as the attractive appearance of the fixtures) may be sacrificed with this intent.

In general it will be found that the contrast of light and shade in some quarters of the room must be sacrificed since the total variation in tone frequently falls outside the available 30:1 ratio. The problem is therefore to make the best compromise possible in the circumstances.

It is sometimes a difficult matter to avoid glare and halation from the sources of light. Sometimes recourse is had to retouching (although even this is no easy matter when the halation exceeds certain limits), but in many cases when scientific accuracy is essential, retouching methods are not desirable. It is then necessary to provide special heavy backing to the plates so that even an object having a surface-brightness of several thousand foot-candles does not lead to halation in the negative. Somewhat similar effects, termed "flare spots," may also arise owing to reflection of the lamps from lens-surfaces, and it is therefore desirable, for this work, to select a type of lens which does not exhibit this defect. In some cases, as for example, when a combination of general illumination from sources outside the field of view, and small local lamps is employed, it is possible to produce the desired effect by merely switching on the latter for an additional short interval of time, so that a good image of the lighted lamps and shades is secured without the general effect being appreciably influenced. In some cases this method has been employed when it has been necessary to take the photograph by daylight, and yet it was desired to show the appearance of the fixtures or chandeliers when lighted up.

The two photographs shown in Figs. 1 and 2 were taken on an historic occasion, namely on the day of the Coronation banquet at the Guildhall. The illustrations refer to two of their Majesties' retiring rooms. The photographs were taken by daylight, but the Holophane spheres were also lighted up for a short period of the exposure.

The following details regarding the surface-brightness of the different objects and the nature of the plate, exposure, &c., may be of interest :—

Plate, Imperial Flashlight (speed no. 300), Stop. F/16
Surface-brightness of carpet 1·0 foot-candles.
" " flowers 0·3 " (mean).
" " oak-beams 0·1 "
" " couch 1·0 "
" " wall below spheres, 2·0
Exposure (based on average of 0·5 foot-candles), 3 min.

Fig. 2 refers to a very similar interior, but with a somewhat darker scheme of decoration. The average surface-brightness was in this case 0·35 f.c., and the estimated exposure four minutes. It may be added that the lights were switched on for fifteen seconds. It will be observed that although no retouching has been employed the spheres appear perfectly distinct, and there is no halation.

The remaining illustration refers to a hall in old English style panelled in oak. It will be noted that the illumination is provided partly by candles and partly by electric lamps on chandeliers. The darkness of the surrounding scheme of decoration may be judged from the fact that, although at the time the photograph was taken (5.30 p.m. in July) there was still plenty of daylight remaining, the exposure needed was a full hour. The photograph was taken by daylight; the lamps and candles were then lighted, and a further exposure of one second given.

The following are the exposure data :—

Plate Imperial Flashlight (speed 300), stop F/16.
Surface-brightness of bright part of carpet.....0·2 f.-c.
" " of top of round table..... 0·07 "
" " of lightest part of oak panel 0·08 "
" " of darkest part of oak panel 0·01 "
" " of blue screen in oak chest ...0·03 "
" " of shadow between chair and table'.....0·015 "
" " of stone of fire-grate.....0·4–1·0 "
Time of exposure (based on 0·025 foot-candles), 60 min.

The fact that an exposure twenty times as great as that allowed in the case of Fig. 1 was predicted, and found to answer, seems to be evidence in favour of the soundness of the Lumeter method of determining exposure.

Two more examples are furnished by the photographs of Gatti's Restaurant in the article following.

FIG. 2.—One of the retiring rooms used by their Majesties on the occasion of the Coronation Banquet at the Guildhall (London).

FIG. 3.—Photograph of Oak Hall in Old English style, lighted by electric lamps and candles.

It may be added that a considerable number of photographs taken on this plan have appeared in *The Illuminating Engineer* for example, The Gas-Illuminated Lawn Tennis Courts (May, 1911, p. 27), The Illumination of a Bakery [arc lamps] (July, 1911, p. 406), The Coronation Illumination of White's Club [tungsten lamps] (Aug., 1911, p. 470), The Illumination of the Cabins' Restaurants [tungsten lamps] (Aug., 1911, p. 477), &c., in these cases the photograph being invariably taken by artificial light. Objects illuminated by mercury vapour lamps have also been successfully treated in the same way.

An Interesting Example of Restaurant Lighting.

In the last number of *The Illuminating Engineer* some remarks were made on restaurant lighting. It was pointed out how greatly the style of illumination adopted varies according to the class of business catered for. In a restaurant intended mainly for casual visitors, who merely drop in for a hasty meal and then depart, a fairly bright and cheerful general illumination is desirable, and chandeliers with exposed sources are very general; but when the customer means to dine at his ease, and to use the occasion for conversation with friends, a more subdued "cosy" system of lighting is usually aimed at.

Another interesting example of these two methods of illumination is provided by Gatti's Restaurant in the Strand, London. By the courtesy of the manager, permission was given for some photographs of this restaurant to be taken, showing the lighting adopted.

Apart from the fact that the installation is a striking one, the method employed in the table d'hôte room being particularly novel and effective, it is of interest to recall that this is said to have been the first electrically lighted restaurant in London. Originally, in the eighties of the last century, a small plant was put down in the basement room (now used as a wine cellar), and was intended only for the restaurant itself. So attractive did the new method of lighting become, however, that before long the company were also supplying electricity to adjacent concerns, and an extension of plant was necessary. Eventually a separate company was formed to supply electricity, and this was the origin of the Charing Cross Electricity Supply Company of to-day.

Fig. 1 shows the method of general lighting adopted in the main part of the restaurant. It is of interest to recall that the chandeliers are the identical ones put up when the electric lighting was first installed, and at that time were unique of their kind. This room may be taken as typical of the method of lighting generally adopted for customers who pay a casual visit and prefer a bright general illumination.

Fig. 2 shows the interior of the table d'hôte room, which corresponds with the "restful" system of illumination. The main lighting is supplied by four inverted units, each carrying a 400 c.p. tungsten lamp, which is screened from the eye by a red silk shade. The light is thrown on the ornamental gilt ceiling and has a very unusual and striking decorative effect. The individual tables are also lighted by local lamps equipped with red silk shades. The illustration serves to show the main features of the room, but gives no idea of the colour effect. This effect has been recorded by taking a photograph in natural colours on a Lumière plate, which, however, is not readily capable of reproduction.

FIG. 1.—Showing general illumination by chandeliers, Gatti's Restaurant, Strand, London.

FIG. 2.—Illumination by indirect lights under gilded ceiling : local silk-shaded table-lamps.

In conclusion it may be of interest to give some particulars of the data on which the exposures for these photographs were based, the method being to determine the surface brightness of the most important objects in the room by means of the Holophane Lumeter, as described in the previous article. The exposure for the colour photograph referred to above was also based on these data.

In the case of the room shown in Fig. 1 no exhaustive survey was necessary. An exposure of one minute, based on an average surface brightness of 2 foot-candles was given, an Imperial Flashlight plate (speed 300) and a stop F/16 being used.

In the table d'hôte room the same type of plate was used and a stop of F/22. The surface brightness of the chief objects of interest was as follows :—

White tablecloths, 2·6 foot-candles, chiefly daylight.
White pillars at back, 1·3 foot-candles.
Red carpet, 0·4-1·3 foot-candles.
Gilt ceiling, 20 foot-candles (above tungsten lamps).
Dark curtains at back, 0·3 foot-candles.
Exposure 4½ minutes (based on average surface brightness of 0·5 foot-candles).

An exposure of half this period (2¼ minutes) was also tried, bearing in mind the great range of tone caused by the daylight streaming through the windows, as well as the artificial illumination. It proved better in bringing out the tone of the lighter objects, but was less satisfactory in displaying the chief objects of interest, *i.e.* the inverted fixtures with red silk shades and the illuminated gilded ceiling.

Artificial Lighting in a Photographic Studio.

In a paper by T. C. Turner, published in *The British Journal of Photography* a short time ago, attention was drawn to the great developments that have taken place in recent years in the artificial lighting of photographic studios, especially in the application of the arc lamp and the mercury vapour lamp. The constancy of the illuminating source and the ease with which light and shade effects can be controlled both favour the use of artificial rather than natural light. The arc being, however, a point source, has to be equipped with some diffusing arrangement, which may in some cases considerably reduce its efficiency. The author refers to the use of white blinds or curtains, of silk or other translucent material, behind which the arc is fixed, thus producing a source of sufficiently low intrinsic brilliancy. In some studios the light from the arc is reflected on to a white ceiling and walls, the lamps themselves being entirely screened. Correct tones for coloured objects are stated to be obtained satisfactorily by the light of an arc if a special light filter is placed between the light and the subject.

The introduction of the mercury vapour lamp has opened up a new field in photo-printing, but its application to studio lighting is limited by its unusual colour, although it is suggested that this is more a question of the personal objection of the sitter than of any real defect in the light. Two ways are mentioned which have been used for correcting the colour of the mercury lamp. One is to supplement its light with that from a group of glow lamps, thus adding the missing red rays; the other consists in the use of a reflecting screen made of cloth dyed with rhodamine, which, when exposed to the light, fluoresces and emits red rays, the latter combining with the rays from the lamp itself to give a light having a fairly continuous spectrum.

Short Notes on Illuminating Engineering.

From all Sources.

Factory Lighting and the Prevention of Accidents—Further Action Needed.

ALTHOUGH reference to the question of industrial lighting has been made in the reports of H.M. Inspector of Factories, and in the recent report of the Departmental Committee on Accidents, there can be little doubt that the subject has not yet received as much official attention in this country as it deserves. A great deal of useful work has been done by the Illuminating Engineering Society—quite sufficient to show what an important part effective lighting plays in the conservation of vision and the prevention of accidents, and quite sufficient to warrant us in following the example of France and bringing the whole subject under State supervision.—*Journal of the Royal Society of Arts*, August 18th, 1911.

Electric Illumination at a Religious Festival.

IN the section of New York known as "Little Italy" there is held every year a great gathering of Italians from all over America to celebrate the festival of Our Lady of Mount Carmel. The celebration lasts for three days, and has always been accompanied by special illumination of the streets and buildings in the quarter.

Formerly the illuminations were mainly carried out with small kerosene oil lamps in coloured glass cases, but four years ago one of the managers of the New York Edison Company saw in this festival an opportunity for the development of electric lighting, and the inhabitants of "Little Italy" having seen what could be done with electric lamps, have since used them very extensively.

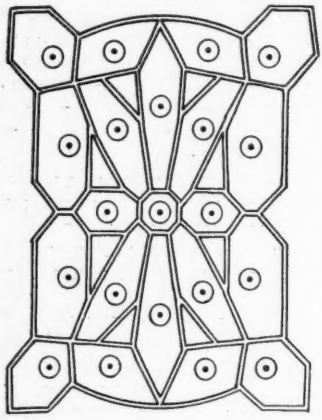
This year, according to *The Electrical World*, many thousands of glow lamps have been used, and some striking effects were produced. The front of the church around which the festival centres was festooned with lamps, the American and Italian flags were reproduced in outline, and an illuminated picture of Our Lady of Mount Carmel was arranged, 300 lamps being used for this. Altogether fully 10,000 lamps are said to have been employed, and the effects seem to have aroused much enthusiasm among the "pilgrims" and the local inhabitants.

Lessons in Gas Salesmanship.

ACCORDING to *The Illuminating Engineer* (N.Y.) a correspondence course on the above subject has just been started by the National Commercial Gas Association. Its purpose is to give more direct and systematic instruction than could possibly be obtained during the period of an ordinary apprenticeship. A number of the leading experts in gas salesmanship have contributed towards the production of the lessons, and it is stated that the proposal has been well received by the gas industry, over 400 students having already subscribed for the course.

The "Talking" Sign.

A RECENT development in electric signs, which consists in producing a succession of advertisements on a single board, is described in *The Electrical Review* (New York). The effect is obtained by building up the sign out of any desired number of monograms or units, each of which is capable of forming any letter or figure. A mechanical commutating arrangement, operated by a small motor, causes any particular selection of letters to flash at one time, and this can quickly be followed by



another announcement. The unit is usually made up of 21 lamps arranged as indicated in the diagram; the maximum number of lamps required for any one letter is, however, only 9. Each lamp is placed in a separate metal compartment, which serves to confine the light, and to preserve a clear definition of the letters. Any complete sentence can be flashed by properly setting the mechanism, and the length of time allowed for each announcement can be regulated by a change in the speed gear.

Better Illumination and the Decline of the Drinking Habit.

In nine years the average annual expenditure on intoxicants has fallen (in England and Wales) from £4 10*s.* 9*d.* per head to £3 7*s.* 6*d.* Deaths from alcoholism have fallen from 113 per million to 47 per million. This is good news, and will be looked upon by most people as a great step in the right direction. Without wishing to rob the temperance societies of any credit due to them, we must express an opinion that the improvement is due to many causes, among which may be counted education, improved housing, increased facilities for bodily and mental recreation, and improved lighting. The last mentioned is of more importance than may appear at first sight; it was from badly lighted homes, and badly lighted places of resort, that men were wont to go to the public-house to spend their evenings. There is also the consideration that many men do not like being seen in a well-lighted street except in a condition of undoubted sobriety.

Co-partnership Journal, July, 1911.

Effects of too Much Sunshine.

ALTHOUGH the sun has always come in for considerable praise as a germicide, it has been suggested in one or two quarters recently that too much of it may have certain ill effects. *The Lancet*, commenting on the coincidence of the present labour discontent coming at a time of prolonged heat, suggests that possibly an overdose of sunshine has reduced the energies of the workers to a point at which striking is preferable to working. The inability of white races to colonize certain tropical countries is cited as an example of the actinic influence of excessive sunlight, to which it is attributed rather than to the heat or humidity.

Another curious case of apparent ill effects from sunshine is noted in *The Daily News*. A local medical officer of health at Grimsby has pointed out that among the cases of enteric fever with which he had to deal, a large number occurred in a particular street on one side of the road only, where the back yards got all the sun, while the other side was practically immune. In replying to a query as to the cause of this, the doctor said that of course the sunshine attracted the flies, and as they were largely responsible, perhaps it was not fair to blame the sunshine entirely.

Tungsten Drawn Wire Lamps and Illuminating Engineering.

On Wednesday, August 16th, a number of representatives of the technical and daily press paid a visit to the works of the British Thomson Houston Co. in Rugby, at the invitation of the Company.

The visitors were conducted over the works and had an opportunity of seeing the manufacture of the new drawn wire tungsten "Mazda" lamps; subsequently they were entertained to luncheon, when Mr. Sparborg, one of the directors, gave an account of the qualities of the new lamp.

Tungsten lamps, it was explained, had hitherto been made on the squirting principle; the filaments consisted of isolated particles of tungsten elaborately welded into a homogeneous state, and the results secured have been a remarkable testimony to the skill and determination of the inventor. Such lamps have been regarded as a great advance. There were, however, certain difficulties. Originally breakages of the brittle filaments were notoriously frequent, and, although considerable progress in methods of support had been made, metallic filament lamps still required to be handled with considerable care.

In all these methods, however, it was not possible to obtain the tungsten filament in a continuous length of wire (as had been done in the case of the tantalum lamp), and it is only recently that the British Thomson-Houston Co. have succeeded in constructing tungsten filaments of drawn wire, which are claimed to be far superior in durability to those of the squirted type. Instead of short and brittle lengths welded to the supports at four or five points, it is merely necessary to wind the ductile wire from a reel on to a suitable spider within the bulb and the operations of mounting, &c., are considerably simplified. In addition to the gain in strength and durability, filaments, which are very homogeneous, are claimed to be produced by this means. Lamps in the 50 and 60 watt sizes are already available for all voltages from 200 to 260 volts, and in all standard sizes from the 10 watt 25 volt to the 60 watt 130 volt lamp. The 17 watt 100–130 volt lamps, and the 32 watt 200–260 volt lamps, and *all* other sizes of Mazda lamps, will also be made with drawn wire filaments, but will not be ready for delivery before October 31st, 1911.

It was, however, explained by Mr. F. W. Willcox, who followed Mr. Sparborg, that it is not only on the lamp itself that success depends, but upon the way it is used. The British Thomson-Houston Co. had determined to establish an illuminating engineering department, which would give advice to consumers as to the best method of using the Mazda lamps so as to secure good illumination. They had also adopted the system of installing a certain number of lamps free for large consumers; this was in order to demonstrate the benefits of good illumination and in the expectation that the consumer would, after once seeing what could be done in this way, arrange for the improved system of lighting to be extended. He could recall cases in which consumers did not properly appreciate the need for good lighting, and, previous to the experiment, they had assured the company that in no case would they bother to make a change. Nevertheless the company persevered, and the demonstration had nearly always come

as a revelation and led the consumer to change his mind.

In all this work it was essential not only to supply efficient lamps, but to see that they were properly used ; and they were training up a special illuminating engineering staff to deal with this matter. It must also be recognized that, to secure successful results, the lamp must be provided with an appropriate reflector, and they had been developing combinations of Mazda lamps and Holophane reflectors. These combinations were supplied as a single unit and selected so as to distribute the light in exactly the way the local circumstances demanded.

Mr. Leon Gaster (Editor of *The Illuminating Engineer*) briefly replied, thanking the company for the invitation to be present. As one who had been interested in the illuminating engineering movement from its commencement, it was most gratifying to him to see how the subject of illumination was being taken up in all quarters by engineers, architects, and hygienic authorities alike. Mr. Gaster proceeded to give a summary of recent progress in these respects, laying special stress on the attention now being paid to the hygiene of illumination in Governmental departments. He was delighted to see that the principles of good illumination, and the choice and arrangement of lamps and fixtures, were being studied by the company. The policy would doubtless bring its reward. It required enthusiasts, and he was glad to observe that the company had at its command both enthusiasm and trained technical ability among the members of its staff.

A portion of the Lamp Works of the British Thomson Houston Co., Ltd., Rugby.

A CORRECTION.

Our attention has been drawn to the fact that the photograph reproduced on page 469 in our ast number was, through a clerical error, incorrectly described ; the illustration in question (Fig. 1) referred to the Kensington Town Hall, which was illuminated by Messrs. Siemens Bros., Ltd., with Carbon Filament lamps and Bro-ite strip.

REVIEWS OF BOOKS.

ILLUMINATION, ITS DISTRIBUTION AND MEASUREMENT.

By A. P. Trotter.

(*Macmillan & Co., Ltd., St. Martin's Street, London, Price* 8*s.* 6*d. net.*)

During the last few years the subject of photometry and scientific illumination, from being of purely philosophical importance, has come to be regarded as of industrial importance. Many noteworthy developments have taken place. The text books of a few years ago are already obsolete, and the time is therefore ripe for a work bringing our knowledge up to date, and reviewing the numerous investigations that have recently been made. Readers of this journal, who have had the pleasure of studying Mr. Trotter's articles will be prepared to welcome such a work, and we venture to think that other students of the subject will be equally interested. Mr. Trotter has long been identified with the study of photometry and the scientific aspects of illumination, and in this book he has been markedly successful in grafting a summary of recent events on to an explanation of fundamental principles.

The first two chapters deal with units and standards, and derived quantities. An up-to-date account is given of the development and present position of the various standards, reference being made to the "international" candle, and the results of the most recent investigations on the Harcourt lamp. The second chapter is concerned mainly with the explanation of such terms as "Illumination," "Intrinsic Brilliancy," and "Flux of Light": and the third and fourth deal with the distribution of illumination, the height and spacing of street lamps, &c.

Chap. v. deals with photometers. After some introductory remarks on the nature and objects of photometry the author proceeds to give brief descriptions of many of the forms of instruments now available, from the Rumford to the Lummer-Brodhun. Reference is also made to the combination of diffuse and regular reflection from most surfaces and the "angle-errors" which are supposed to be associated with wedge forms of photometers. The chapter following discusses accessory apparatus. Some sound advice is given respecting the use of screens, the avoidance of stray light, and the selection of scales for the photometric bench and the author's form of automatic recorder is described.

Chapter vii. deals with methods of studying the distribution of light from a source and obtaining polar curves. A succinct account of the considerable amount of work recently done in this section is given, including the apparatus of Ulbricht, Blondel, Wild, and others, and the various constructions suggested for obtaining mean spherical candle-power.

Chapter viii. on the photometry of coloured lights may be recommended to those interested in this difficult subject. Much has been written on its complexities. We know of no better summary of the present position than that given here, which enables the student to discriminate between questions which are of real practical importance and those which are mainly of scientific interest. The account of flicker photometers is excellent. It is pointed out that the "Purkinje Effect," with all its uncertainties and mysteries, is only of consequence at very low illuminations and under conditions that are hardly likely to occur in practice. The subsequent chapter dealing with errors is also instructive, a clear distinction being drawn between the degree of precision aimed at in the laboratory, and that considered desirable in the case of practical work with illumination photometers. Chapter x. on the measurement of illumination contains a fully illustrated and complete description of illumination photometers. Chapter xi. presents some examples of the measurement of illumination, mainly in various streets in London, and Chapter xii., on the dioptric distribution and diffusion of light, traces the development of this principle from the date of the author's pioneering work on the subject up to the Holophane reflectors of to-day.

The book concludes with an admirable bibliography in which the references, (already given at the foot of the pages on which they occur) are collected together and repeated in alphabetical order. There is also an adequate index and the illustrations (over 200 in number)

are throughout excellent, and, indeed, unique in a book of this kind.

The author recalls that the germ of the work now issued is to be found in the well known paper by the author read before the Institution of Civil Engineers in 1892; sixteen years later this paper was re-written, and appeared in the form of a series of articles recently concluded in *The Illuminating Engineer*. It has now been revised and considerably extended, and is issued as a separate volume.

Those who are acquainted with these previous publications cannot fail to be struck by the numerous modifications and additions which the rapid progress in the last few years have rendered necessary, although the inimitable and interesting style of the original work has been preserved. In conclusion we venture to hope that Mr. Trotter will continue to subject this book to the frequent revision which changing conditions demand for we recognize that it satisfies a want that has been persistently making itself felt during the last few years.

Some Publications Received.

The Journal of Industrial Safety. A journal published by the Industrial Safety Association (of New York) and devoted to the spread of knowledge with regard to the causes and prevention of accidents.

Human Engineering. A new monthly magazine dealing with efficiency in industry from the point of view of the physical and mental condition of the workers.

On the Absolute Measurement of Light: a Proposal for an Ultimate Standard of Light. By R. A. Houstoun. An interesting suggestion to use a thermopile in conjunction with a light filter so arranged that the deflections of the galvanometer would be proportional to the light received.

Subjective and other Phenomena connected with the Retina. By Dr. F. W. Edridge-Green. A reprint from the *Journal of Physiology*, in which the author gives some further account of his researches on the yellow spot phenomena, &c.

The Discrimination of Colour. By Dr. F. W. Edridge-Green. A communication presented before the Royal Society, May 18th, 1911.

Zeitschrift für wissenschaftliche Photographie Photophysik und Photochemie.—This number contains an interesting paper by E. Goldberg dealing in an experimental and theoretical manner with the question of detail in photographs and its connexion with exposure of the negative.

Report of a Special Committee of the London Chamber of Commerce on the National Insurance Bill.

The Physical Review. The *Proceedings* of the American Physical Society, reported in this number, contain several contributions of interest in illumination and photometry, to which we have referred elsewhere.

Proceedings of the American Philosophical Society. This number contains a note on 'Self-luminous Night Haze,' by E. E. Barnard.

L'Éclairage à l'Incandescence par le Gaz. By Paul Lévy. We hope to refer more fully to this work shortly.

British Weights and Measures. The official journal of the British Weights and Measures Association, a society formed for the purpose of defending the present system of weights and measures in this country.

A Form of Neutral Tint Absorbing Screen for Photometric Use. By H. E. Ives and M. Luckiesh (reprinted from *The Physical Review*). We referred to this in a note in our last issue (p. 484).

Note on Crova's Method of Heterochromatic Photometry. By Herbert E. Ives (reprinted from *The Physical Review*).

The Measurement of Light. A reprint of two lectures delivered by Dr. C. H. Sharp at the Johns Hopkins University, October, 1910.

We have also to acknowledge the receipt of the following: *Proceedings of the Faraday Society, Journal of the Royal Society of Arts, Journal of the Royal Sanitary Institute, Journal of the Institution of Electrical Engineers, Transactions of the South African Institute of Electrical Engineers, American Chemical Journal, Journal of the Franklin Institute, Proceedings of the American Academy of Arts and Sciences, University of Illinois Bulletin, Proceedings of the Tokyo Mathematico-Physical Society, Archives du Musée Teyler, Atti della Associazione Elettrotecnica Italiana.*

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Light Transforming Reflectors for Mercury Vapour Lamps.

By the courtesy of the **Westinghouse Cooper Hewitt Co.** (151–2, Great Saffron Hill, Holborn Circus, London, E.C.) a representative of *The Illuminating Engineer* recently had the privilege of seeing in operation the new rhodamine light transforming reflectors, a new invention of Dr. Cooper Hewitt. The reflector is of the trough shape and fits over the mercury tube so as to direct its light downwards. Its surface is coated with a red material (composed mainly, we understand, of rhodamine) which has the property of strongly fluorescing in the light of the mercury lamp, converting some of the excess of light of small wave-length into visible red rays.

The appearance of the reflector when the lamp is lighted bears out this suggestion. Its surface appears red by daylight. But whereas an ordinary non-fluorescent red material would appear black by the light of the mercury lamp, this reflector still retains its vivid colour, although there is a distinct difference in tint from that seen by daylight. Coloured objects seen by the light of the combination preserve their correct tint much better than in the case of the ordinary tube without a reflector, and the rhodamine surface is stated to preserve its qualities for a long time. The reflectors on view at Saffron Hill are experimental ones, but it is stated that they will be put upon the market as a regular feature very shortly.

Fans.

The season just passing must have been a record one for the providers of ventilating fans. **Messrs. Veritys, Limited** (31, King Street, Covent Garden, London, W.C.) have sent us a price list of some of the varieties of fans made by them, from large ventilating fans moving as much as 18,000 cubic feet of air per minute, down to portable fans, which will fit an ordinary lighting pendant.

In a list of fans received from **Messrs. The Sun Electrical Co.** (118–120, Charing Cross Road, W.C.) we notice a novelty in the way of a COMBINED FAN AND

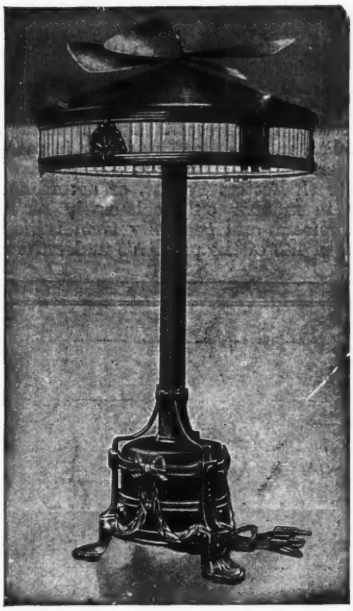


TABLE LAMP, the fan being fixed on the axis of the lamp immediately above the shade. The driving motor is fitted in the ornamental base of the standard as indicated in the above illustration.

Adjustable Fittings.

Messrs. Dugdill (Failsworth, Manchester) have sent us a card on which are summarized briefly the chief types of MOVABLE ELECTRIC LIGHT FITTINGS, the manufacture of which they have made a speciality. We notice several pendants with flexible joints which should be very serviceable in factory lighting where it is essential that the light over a machine should be under the control

of the operator, and should be capable of being placed in any desired position with regard to the work in hand.

Metal Lamp Patents — Another Osram Action—Important Decision.

In an action brought in the Chancery Division of the High Court of Justice by the Osram Lamp Works, Ltd. against the British Tungsten Lamp Co., Ltd., and another for infringement of Letters Patent, an order was, by consent, made on the 26th day of July, 1911, whereby it was (among other things) ordered that the defendants, their servants, agents, and workmen be restrained during the continuance of certain Letters Patent from importing into, and from making, selling, offering for sale, supplying and using in this realm any illuminating bodies or electric lamps containing illuminating bodies, made according to, or in manner described and claimed in the specification of such Letters Patent, or according to, or in manner only colourably differing therefrom, and generally from infringing the rights of the plaintiffs under the said Letters Patent, AND that the defendants do pay to the Plaintiffs the sum agreed for damages sustained by the plaintiffs, or to be sustained by reason of the infringement of the said Letters Patent by the defendants by the manufacture and sale, prior to the date thereof, of lamps and filaments, and the sale of the lamps then in stock, or by reason of the user of such lamps and filaments, AND that the defendants do pay to the plaintiffs their costs of the said action to be taxed by the Taxing Master.

Entrance to Earl's Court Exhibition—Price reduced to 6d.

Our attention has been drawn to the fact that the entrance price at Earl's Court Exhibition was, on Tuesday, August 8th, reduced from one shilling to sixpence.

It is pointed out that London is the only city in the world that has made a practice of charging more than sixpence for admission to outdoor places of entertainment, and no doubt this change will lead to a substantial increase in the number of visitors.

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Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

ONE of the chief recent events of interest has been the meeting of the **International Photometric Commission** in Zürich. The papers presented on this occasion have been noticed in various technical journals, especially the *Journal of Gas Lighting*, and are dealt with elsewhere in this number.

One of the most interesting papers is that by W. J. A. BUTTERFIELD, J. S. HALDANE, and A. P. TROTTER, regarding the **Effect of Atmospheric Conditions on Photometric Standards.** The experiments were carried out in a special chamber so that either of the important factors, humidity, barometric pressure, or production of CO_2 at the expense of oxygen in the air, could be studied *separately*. By artificial means it was also possible to secure a far greater variation than would be met with in practice. The experiments confirm completely C. C. Paterson's data for the Harcourt Pentane Lamp, but it appears that the effect of barometric pressure on the Hefner lamp somewhat exceeds that generally assumed. Vitiation of the atmosphere is an important item.

Of the other papers that by EITNER is of a general nature, summarizing **Photometric Methods in Germany.** H. STRACHE suggests a method of establishing an **Absolute Standard of Light.** This is based on the artificial production of a distribution of energy in the spectrum of a black body equivalent to the known luminous efficiency curve. J. THOVERT describes a simple form of **Spectrophotometer** which is intended for use on an ordinary photometric bench.

Another item of interest is the paper by J. DARCH on **Hospital Lighting** read at the Congress of the Royal Sanitary Institute. This, too, is dealt with in the present number, and need only be mentioned here. The chief points brought forward are the unsatisfactory nature of the shades and the positions of lights in many hospitals, and the need for specially designed illumination in the operating theatre. In the wards of a hospital the lights should be arranged in such a way that they are not troublesome to the eyes of patients. In the operating theatre methods of reflecting the lights from an arclamp to and fro, so that it strikes the table from all directions, are sometimes employed.

The *Transactions* of the American Illuminating Engineering Society for June contain several interesting papers. G. E. STICKNEY deals with **Mill-lighting,** and makes some general remarks on the amount of illumination required for rolling mills, spinning works, &c. For general lighting 3/4 to 2 foot-candles is customary, in machine shops for fine work 3 to 6, in spinning and carding rooms 1 to 4. A very vital matter in all these cases is *the direction* from which the light comes. The workman can often give hints to the illuminating engineer as to the best positions of lights, so as not to cast objectionable shadows on his work.

S. W. ASHE presents an exceptionally complete set of data on the **Life and Efficiency of various Illuminants.** The paper gives rise to very lengthy discussion, exception being taken to some of the results, notably the fall in candle-power during the life of incandescent mantles and mercury vapour lamps. Another point calling for comment is the amount of gas consumed by the pilot flames in some of the burners tested; this ranges from 0·1 to 0·5 cub. ft. per hour.

In passing, reference may be made to another article reviewing illuminants, that of TAPPLEY (*Elec. Review*, July 21st, 28th). Life curves for tungsten lamps and incandescent mantles are also given here, the fall in candle-power during the first 500 hours being returned as of the order of 50 per cent.

An article on **Street Lighting** by W. T. RYAN (*Elec. Rev.*, N.Y., July 15th), contains a series of curves showing the

distribution of illumination between two of a row of lamps of various kinds, including the magnetite arc. He also refers to the method of specifying street illumination advocated at the last meeting of the National Electric Light Association. This prescribes that illumination should be measured normally at a distance of 250 feet from the foot of the lamp tested.

Quite a number of journals comment upon the article recently published in these columns on **Standard Specifications for Street Lighting,** in which the views of a number of Continental authorities were tabulated. A notable event has been the acceptance of the combined specification by the gas and electricity supply companies for Holborn.

One other article on photometric instruments deserves mention, namely, the description of the **"Chromoskop,"** contributed by L. ARONS (*E.T.Z.*, July 27th). The instrument makes use of polarized light to produce a variety of tints, and it is stated that any shade of colour can be exactly imitated and reproduced by this means.

ELECTRIC LIGHTING.

There are again relatively few important articles in this section to be recorded.

The contribution of G. DETTMAR, dealing with the application of electric lighting and heating in private houses, and methods of making them attractive to the private consumer, is now completed (*E.T.Z.*, July 20th).

ESCARD (*L'Électricien*, Aug. 12th) summarizes some of the work that has been done in connexion with **Metallic Electrodes for Arc Lamps.** Although many researches on this point have been carried out, there have been few practical applications, the class of lamps using magnetite and titanium oxides and the employment of iron electrodes in the Finsen arc being among the few well-known examples. On the other hand, aluminium, copper, and some alloys of these metals, have shown certain promising qualities in the laboratory.

O. KRUH (*Elek. u. Masch.*, July 23rd) reviews the existing methods of **Starting Mercury Vapour Lamps.** These include tipping the lamp (either by hand or electromagnetically) so as to bring the mercury electrodes into temporary contact; the application of a momentary high P.D. to produce a discharge; the use of a small subsidiary electrode where a small arc can be started and electrons produced which rapidly find their way through the entire tube; the use of a small local heating coil above the mercury, which has the same effect. An article in the *Zeitschrift für Beleuchtungswesen* (July 30th, Aug. 10th) covers somewhat similar ground. Stress is laid on the principle that some means must be employed to prevent the mercury gradually accumulating at the negative pole, and some patents designed to control the level at the positive end and prevent this effect are described.

GAS, OIL, ACETYLENE LIGHTING, &c.

There are a number of communications in the United States technical press to be noted. That by N. J. COOKE (*Am. Gaslight Jour.*, Aug. 7th) is concerned with gas salesmanship and the best method of approaching the public. Stress is laid on the importance of securing the services of an illuminating engineer, and a constant policy of keeping consumers' lighting up to date; besides renewing mantles and adjusting burners, the globes are cleaned, and, when necessary, taken back to the works for the purpose of being temporarily exchanged for new clean ones. G. R. CHAMBERLAIN (*Prog. Age*, Aug. 1st) describes an unusual and new style of **Lamp Posts for Gas Lighting.** They are very simply and solidly constructed, and are painted a dead white.

The Theory of Electric Ignition by heated wire is dealt with by two authors, H. LYON (*Am. Gaslight Journal*, July 24th) and R. F. PIERCE (*Illum. Eng.*, N.Y., August). It is pointed out that the temperature of the wire, besides being raised to a certain point by the electric current, is carried still higher by catalytic action. The object in designing the arrangement must be to keep this accentuation of the temperature within limits. A baffle plate is also introduced to keep the products of combustion from coming in contact with the filament, and to enable it, when in the heated condition, to be scoured with a current of fresh air; this is said to enable it to keep in working order for a much longer period.

Other articles deal with developments in gas lighting in Germany. A map is given (*J. f. G.*, July 15th) showing the spread of high pressure gas lighting in Berlin, and contrasting this with the electric development in that city. SCHOLZ (*J. f. G.*, Aug. 5th) discusses some figures given by W. Wedding relating to

gas and electric lighting, and also gives an account of **Progress in Low Pressure Lighting.** So much attention has recently been bestowed on high pressure street lighting that the remarkable progress in low pressure lamps is apt to be overlooked. Scholz claims that with the newest lamps only 0·6 litres of gas per H.K. (nearly 40 c.p. per cub. ft. of gas) can now be obtained. The question of low pressure lamps versus high pressure for shop-lighting is also dealt with in the *Gas World* (Aug. 19th). It is pointed out that, in view of recent progress in efficiency of low pressure lamps, it is doubtful whether it is often worth while to go to the expense of putting in a compressor and special lamps.

G. SCHUCHARDT (*Z. f. B.*, July 20th) has devised an inverted burner on a new principle. In the ordinary type there is an ascending "counter-stream" of air which meets the main flow of gas through the burner, and is necessary to combustion. It is suggested that the tendency to light back in some inverted burners, and a certain unsteadiness in action, are due to this impinging current of air. He has therefore adopted a type of burner which permits the necessary amount of air to be fed to the gas before it emerges. The flame can thus be completely enclosed, and it is claimed that a steadier and more efficient lamp is secured as a result.

Among other articles we may note an account of the use of gas for **Railway Carriage Lighting** (*Gas World*, July 22nd, Aug. 19th) and a review of recent patents on the details of burners for liquid fuel (*Z. f. B.*, July 30th).

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Photometric Nomenclature (*Electrician*, Aug. 18).
The International Photometric Commission (*J.G.L.*, Aug. 1, 8).
The Standard Street Lighting Specification (*J.G.L.*, July 25).
Holborn Public Lighting—Joint Tender Accepted (*J.G.L.*, Aug. 1).
Factory Lighting (*Elec. World*, N.Y., July 15).
A New Method of Water Sterilization by Ultra-violet rays (*Canadian Engineer*, July 13).
Bericht der Lichtkommission der Deutschen Verein von Gas und Wasserfachmänner (*J. f. G.*, July 29).
Illumination at the Turin Exhibition (*Illum. Eng.*, N.Y., August).

ELECTRIC LIGHTING.

Dettmar, G. Die Elektricität im Hause (*E.T.Z.*, July 20).
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Bowlin, M. A. Interior Illumination with Small Units (*Prog. Age*, Aug. 1).
Chamberlain, G. R. An Ornamental Street Lamp-post Installation (*Prog. Age*, Aug. 1).
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Editorial. High or Low Pressures for Shop Lighting? (*G. W.*, Aug. 19).
Lyon, H. Filament Ignition of Gas (*Am. Gaslight Jour.*, July 24).
Pierce, R. F. A New System of Gas Lamp Ignition (*Illum. Eng.*, N.Y., August).
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Gastarklichtlampen zur Strassenbeleuchtung in Berlin (*J. f. G.*, July 15).
Gas and Electric Street Lighting in Berlin (*G.W.*, Aug. 5).
Gas for Railway Carriage Lighting (*G.W.*, July 22, Aug. 19).
Neuere Brenner und Lampen für flüssige Brennstoffe (*Z. f. B.*, July 30).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
J. G. L.—*Journal of Gaslighting.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*
T.I.E.S.—*Transactions of the Illuminating Engineering Society (U.S.A.).*

Illumination: its Distribution and Measurement.

By **ALEXANDER PELHAM TROTTER.** Illustrated. 8vo, 8*s.* 6*d.* net.

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EDITORIAL.

An International Committee on Illumination.

IN our last number we drew attention, while referring to the work of the International Photometric Commission, to the great work to be accomplished by an international committee on illumination. This suggestion is enlarged upon by the writer in the paper delivered at the International Electrical Congress in Turin, and abstracted on p. 569 in this number. Such a Commission could do valuable work in reconciling the conflicting ideas on nomenclature, symbols and photometric measurement, and there is an equally important field before it in connexion with more practical problems, such as the nature and amount of illumination required for different classes of work, &c.

The proposal met with general approval at the Congress, and there seems no reason to doubt but that some organization for collecting together and bringing into line the work being carried out independently by various bodies would be welcomed by all concerned with illumination. In carrying out this scheme the help of the Illuminating Engineering Societies would be very valuable. The Society in this country is international in scope and includes among its members representatives of practically all the existing committees which investigate lighting matters. In the same way the American Society exerts a vast influence in the United States and can most effectively represent the views of lighting experts in that country.

The suggestion that the International Electrotechnical Commission should work in co-operation with these Societies was brought forward by the writer at the meeting of the Commission in Turin, and received warm

support from Dr. A. E. Kennelly, the President, and Dr. Clayton H. Sharp past President of the American Illuminating Engineering Societies.

A most important resolution on the same subject was also passed unanimously at the meeting of the International Electrical Congress which followed. It was resolved that:—

> "This Congress deems it desirable that an International Commission should be nominated in order to study all systems of lighting and technical problems connected therewith; and, having been informed that the Illuminating Engineering Society of London has the intention of forming such a Commission, and of putting itself in touch with the other existing national and international photometric Committees, approves their taking the initiative in this respect."

It is to be noted that the number of associations and societies interested in these problems has greatly increased of recent years. The Illuminating Engineering Societies in Great Britain and the United States, the Verband deutscher Elektrotechniker and the Verein von Gas und Wasserfachmännern in Germany, the International Photometric Commission and the International Electrotechnical Congress have all shown a keen concern in illumination. Let us hope that the new International Committee on Illumination will be the means of bringing about the much to be desired co-operation on these matters.

The Meeting of the International Electrotechnical Commission.

The meeting of the International Electrotechnical Commission, which took place at Turin from Sept. 7th to the 11th, was generally considered one of the most successful yet held. Over twenty-one different countries were represented, and the addresses delivered were of a most instructive and inspiring character.

The commission is now reaping the reward of the painstaking steady preparatory work that has been going on during the last few years. Agreement was reached on a number of important points, of special interest being the decision that the three chief electrical quantities, current, voltage, and resistance should be represented by I, E, and R, respectively. To attain this result concessions have been made by several countries, England, for example, abandoning the use of the letter C for current, and Germany the employment of W (Widerstand), for resistance. Amid the political differences of these times it is pleasant to see how scientific men of various nations are finding it essential to make arrangements for the common good, thus showing once more that science recognizes no geographical boundaries. As an illustration of the good understanding in this respect it may be recalled that the nomination of the new President Prof. Dr. Budde, who is the President of the Verband deutscher Elektrotechniker and also a Vice-President of the Illuminating Engineering Society, was carried unanimously on the proposition of M. Picou, the President of the French Electrotechnical Committee.

All the proceedings at the meetings of the Commission were of the most agreeable and harmonious character, and the precision with which the arrangements were carried out was due in no small measure to the efforts of its distinguished Hon. Secretary, Col. Crompton, and of the hardworking general Secretary, Mr. C. Le Maistre. Special thanks are also due to Prof. L. Lombardi, the President of the Italian Institution of Electrical Engineers, who kindly presided over the unofficial meetings, and to Sig. Grassi and Sig. Semenza of the Italian Local Committee.

It is of importance to note the desire for friendly co-operation with the organizers of the International Electrical Congress. On this occasion the fact that the Congress took place in Turin, immediately after the meet-

ing of the Commission had terminated, was a great convenience to those interested in both gatherings. We may hope that the great success of the gathering in Turin this year will form a valuable and encouraging precedent in this respect. In future the time and place of meeting of the Congresses will be determined by the International Electrotechnical Commission and the organization entrusted to the local Committee, working in co-operation with the various Institutions concerned.

When one considers that the International Electrotechnical Commission only came into existence about seven years ago, the growth of its influence during this period appears a most striking tribute to the persevering efforts of its supporters and the justice of its aims. The electrical industry throughout the world is already deriving substantial assistance from its work and it may be anticipated that these benefits will be found to be even greater as time goes on.

The Illumination required for Various Purposes.

On p. 583 we publish a short article in which some data from various sources recently presented for the illumination of various interiors, schools, factories, concert halls, restaurants, &c., is gathered together. The problem of stating definitely what amount of light is needed in these different cases is now facing hygienic authorities, and it is evident that a great deal remains to be done before precise recommendations can be issued. The problem, however, is simplified by the fact that we have now available simple methods of measurement which enable us to ascertain quickly and easily, and with quite sufficient accuracy for commercial purposes, what the existing illumination in an installation may be. Already we have a constant stream of data, especially from the United States, and it is now becoming customary for the illumination to be measured and stated whenever any new installation is described.

On the other hand, it is difficult as yet to draw definite conclusions from the results presented. There has not, as a rule, been sufficient attempt to consider what the ideal illumination for any specific purpose should be; our ideas are mainly formed on the existing practice, which is not necessarily the best possible. In a few cases, however, notably schools and libraries, the lighting of which has recently been very thoroughly discussed by the Illuminating Engineering Society, we are in a better position. It was found possible to fix with fair precision what the desirable illumination on theoretical grounds should be, and by the aid of actual measurements in many existing schools and libraries to show that these demands could be met and were not excessive. For example, the suggestion that the minimum illumination for ordinary reading purposes in libraries should be three foot-candles, was shown to have a substantial and reasonable basis in theory; and, in addition, data collected in a large number of libraries in London, showed that this figure not only could easily be attained, but, in many cases was even exceeded.

It is only by this union of practice and theory that really reliable judgments on this point can be formed.

Meantime, the advantage of a tentative standard cannot be denied. A mere casual inspection of an installation, although it may lead to suggestions of value, does not enable the visitor to say off-hand whether the illumination is adequate, nor to analyse the conditions and point out exactly where the error lies. Moreover should he consider the illumination insufficient he has no means of maintaining his judgment against a contrary opinion except by an appeal to the measuring instrument.

Assuming, however, that we are in a position to specify a certain illumination, and subsequently to verify, by actual measurement, whether the specification has been complied with,

the question remains how far is it possible to calculate out the illumination before hand, and give a guarantee on this point? The answer is that this can be, and in some cases already *is* done by engineers who are well acquainted with the exact results secured from the lamps and fixtures employed. This knowledge is, however, essential. To make a prediction with reasonable accuracy, one must know the intensity and distribution of light from the lamps and reflectors to be used, and be able to rely on their being standardized so that the same result will always be secured from a given combination of lamp and reflector.

Considerable progress has recently been made towards securing this standardization, and it is now possible to state with fair precision what the illumination obtainable from a given unit, suspended at a certain height, will be. One other circumstance, however, must not be overlooked, namely the effect of reflection from walls and surroundings. Unless an interior has been studied beforehand, so that the reflecting power of these objects is known, a certain "factor of safety" must, of course, be allowed. But it has been shown that the disturbing influence is in practice not so great as might be supposed, and also that by the aid of previous experiment and experience it can be allowed for very completely if particulars of the scheme of decoration are available. It is, however, obviously desirable that the lighting engineer and the decorator should work hand in hand in this matter. If this is done, the prediction of illumination becomes merely a matter of scientific forethought and knowledge.

The Perception of Distant Lights at Sea.

The article by Prof. Blondel on this subject on p. 557 serves to show the complexity of the problems connected with lighthouse illuminants and the perception of distant lights at sea. The requirements in these cases are radically different from those with which the illuminating engineer is ordinarily called upon to deal. It is not so much a question of illuminating value and the "power of creating brightness" by which we judge lamps intended for lighting purposes, as *penetrating power*. This may depend on other things besides brilliancy, such as the ability to shine through mists, &c., for which purpose some colours of light are apparently better suited than others.

Another important distinction is that here we are looking at the source itself, not the illumination it produces. Consequently the very quality which we desire to lessen in the case of indoor lighting, high intrinsic brilliancy, may be the most desirable qualification in a lighthouse illuminant. The visibility of lights at a distance is, however, also intimately connected with the physiology of the eye, and especially its behaviour in viewing very feebly luminous objects. The measure of the effectiveness of a lighthouse illuminant is the distance away the observer has to go before it just disappears from sight; two lamps which are equally useful as illuminants at close quarters may be very different in effectiveness when observed from near their vanishing distance.

The particular problem which is discussed by Prof. Blondel has to do with the effect of flashing lights.

It will be readily understood that, while a steady light might be difficult to see, a flashing light, disappearing and reappearing at regular intervals, might more easily receive attention. Apart from this, flashing is often essential as a mark of distinction enabling the mariner to recognize his whereabouts by the periods of brightness and darkness. The question of the duration of flash is therefore an important one, and the conclusions which Prof. Blondel forms on this subject are of great interest to those concerned with lighthouse illuminants.

LEON GASTER.

Review of Contents of this Issue.

PROF. A. BLONDEL and J. REY contribute an article, which will be found at the beginning of the Technical Section (p. 557), on **the Perception of Lights of Short Duration at their Range Limit.** The authors, after a brief review of the work of other investigators, describe the methods and apparatus employed by them in determining the relation between the retinal impression produced by a given illumination and the duration of the latter, especially at the limiting point. The general principle adopted was to compare a flash of fixed intensity and duration with one in which these quantities could be varied, this variation being carried on until both flashes disappeared simultaneously at the same distance, *i.e.* until they had the same 'range limit.' The observations were made by a large number of observers, so as to eliminate as far as possible the personal error, and the vision of each operator was compared under similar fixed conditions. The authors have applied the new law which they have deduced as the result of their observations to several problems in connexion with flashing lights, used either for telecommunication or orientation.

On p. 563 will be found a contribution from PROF. E. W. MARCHANT and W. PARRY, on **the Effect of Frequent Switching Off and On of Metallic Filament Lamps on their Efficiency and Life.** The object of the tests was mainly to determine whether frequent switching had any effect on the life of lamp filaments, owing to the expansion and contraction which must ensue when the lamp is switched on and off. The switching of the lamps was effected by a contact-piece dipping in a mercury cup, and operated by a cam driven through reduction gear from a small motor. The number of switchings was determined by a revolution counter. The results obtained, both for the switched lamps and those burnt continuously are given in the form of curves of life and efficiency. 72,000 switchings reduced the life by 33 per cent, assuming 1,000 hours as the normal. At the same rate, the author calculates that the switching of a lamp in ordinary practice would reduce its life by less than ½ per cent, hence the effect is negligible.

Some account of the proceedings at the meeting of the **International Electrotechnical Commission,** recently held in Turin, is given on p. 567. Among the important steps taken may be mentioned the confirmation of the letters I, E, and R as the international symbols for current, electromotive force, and resistance respectively, and a decision as to the rating of dynamos and motors, their power in each case to be expressed in international watts. A resolution of special interest was passed, recognizing that in all matters relating to illumination, the national committees should co-operate with the Illuminating Engineering Societies in their respective countries; an important resolution that an International Commission on this subject should be appointed was also passed by the International Congress of Applied Electricity.

An abstract of a paper entitled **The International Outlook in Scientific Illumination** read by MR. L. GASTER at the Congress of Applied Electricity held in Turin, will be found on p. 569.

The author traces the development of the illuminating engineering movement from the foundation of the Illuminating Engineering Society in the United States in 1906. He mentions the important steps that have been taken with regard to legislation on factory lighting on the Continent, the progress that has been made towards framing a standard specification for street lighting, and especially he emphasises the need for international agreement on the symbols to be used

for the more important quantities and terms in illumination. In conclusion, a plea is made for the centralizing and collecting together of the work that is at present being done independently by various bodies working on different lines.

Following this is a brief account of the **International Hygienic Exhibition at Dresden** (p. 573). Attention is drawn to the scientific organization of this exhibition, and the pains that have been taken to show the historical development of the subject. Special mention is made of the remarkable collection of information relating to the human body and its treatment in the hall devoted to 'Der Mensch.' A special section dealt with illumination and hygiene. Here were shown various forms of modern lamps, and also an exhibit showing their historical development. Glare formed the subject of an exhibit by Dr. Stockhausen, who also showed the effect of Euphos glass on ultra-violet radiation.

A list of the papers read at the **Fifth Annual Convention of the Illuminating Engineering Society (U.S.A.)** in Chicago is given on p. 575, and, following this is a short account of the aims and objects of the newly-formed **American Association for the Conservation of Vision.**

Some of the recent developments in connexion with **Luminous Tubes containing Neon** are described on page 576, and this is followed by a note on **Illumination and Industrial Accidents**, with a diagram which indicates the increase in the number of accidents which take place during the darker days of winter.

The Value of Good Illumination to Railway Companies is the subject of an article on p. 579. The importance of good illumination from the point of view of safety is first emphasized, and the appointment of special lighting experts by many of the large railways is mentioned as a recognition of this importance. Subsequently the special conditions met with in the lighting of country stations are dealt with, and the use of electricity and gas is discussed in connexion with signals. Finally some space is devoted to the question of railway carriage lighting, and the various applications of gas and electricity are reviewed. This article is followed by some notes on the new lighting installation at the offices of the L. & S.W.R. (Waterloo Station).

Some notes on **Illumination Requirements for Various Purposes** are given on p. 583. The large increase in the standard of illumination demanded by the public, and also the way in which this standard varies in different countries is illustrated by examples. The main part of the article is taken up with notes gathered from a large variety of sources, and brought together under sections dealing with schools, streets, factories, libraries, &c. In conclusion a table is given which summarizes the views of several different authorities.

Following this is a short description of the **Illumination of the Building of the People's Gas Light and Coke Co. (Chicago),** with a photograph showing the striking bronze gas fixtures which have been installed in the building. Some details are given of the high pressure system in use, and of the pneumatic distance lighting arrangement by which the lamps are controlled.

On p. 590 some of the special features of **Stained Glass Lamp Shades** are discussed, and illustrations are given of two artistic designs. This page is followed by the usual **Short Notes on Illuminating Engineering.**

The section devoted to **Correspondence** contains a letter from MR. A. J. MARSHALL of New York, in which he makes some comments on the article entitled 'Light and Shade in Indirect Lighting,' which appeared in our August issue. This is followed by a letter from MR. J. ECK in which some additional experiments are described disproving Mr. Marshall's criticisms.

On p. 595, our Glasgow correspondent contributes some notes on **Illumination at the Scottish National Exhibition.** He describes in detail some of the principal features in the general scheme of illumination of the buildings and grounds, and also gives particulars of many of the exhibits more especially concerned with illumination.

At the end of the number will be found the usual **Trade Notes** and the **Review of the Technical Press.**

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

On the Perception of Lights of Short Duration at their Range Limit.

By Prof. A. Blondel and J. Rey.*

Objects of Investigation.

The laws of the perception of lights of short duration are of very great interest, not only from a theoretical and philosophical standpoint, but also by reason of the important applications to which rapid signals give rise in practice. Many years ago numerous investigators, such as Helmholtz, Brücke (1886), Exner (1868), Allard (1872), Kunkel (1874), Swan (1849), Charpentier (1887–1890), Broca and Sulzer (1902), Martins (1902), MacDougall (1904), &c., had already devoted themselves to the study of the variation of the luminous sensation as a function of the time.

Bloch originally contended that the excitation necessary to produce an appreciable sensation was practically constant and proportional to the product of the illumination and the time; Charpentier, who has verified this law between certain limits, likewise suggested that the retinal impression e produced by an illumination E of short duration t is fixed according to a linear law $e=Et$.

But we have since been led to infer that the law of Bloch and Charpentier must be replaced by a law in which the period of perception of a light just capable of producing the threshold of sensation should be infinite, and of which the equation would therefore be in the form:

$$(E - E_o)\, t = C.$$

C being a constant quantity.

Not wishing to stop at this theoretical result, we have tried to find out by experiments the law of the relation between E and t (when they produce the limit sensation), whilst taking care to employ a great number of observers, who were kept in ignorance of the anticipated result.

Methods and Apparatus Employed.

The observations have been concerned with "point-sources," that is to say, produced by an artificial luminous source having angular dimensions so small that they cannot be estimated by the naked eye; for it is under this appearance that signals are perceived at a great distance.

All our experiments have been made in the laboratory, in order to avoid the many disturbing causes which are to be met with in the open air, such as the variation of the atmospherical absorption, the effect of surrounding lights, the fatigue of the observers, &c.; it is only in the laboratory that phenomena of this kind can be studied with precision in order to establish approximate laws.

Naturally, the flashes produced by the short lights must succeed each other at rather distant intervals, so that there is no fear of the mutual influence of the two successive impressions; for this reason we have generally adopted a periodicity of about three seconds between successive flashes. Our experiments have been based on the method of equalization, that is

* A short summary of this work was presented by the authors to the Academy of Science of Paris at its meeting on July 3rd, 1911.

to say, by trying to render equal two short flashes differing from each other by the values E and t.

An apparatus which allows of this method being carried out has been studied, under the direction of M. Rey, by M. Marsat, an engineer of the firm of Sautter & Harlé, and has been used for the greater part of these experiments. Another device for this purpose has been constructed according to the design of one of us by M. Camillerapp, constructing engineer.

Rey's Apparatus.—The general principle of this is shown in Fig. 1.

One of the cranks of fixed width E_1 passes in front of the lens L_2 and causes a flash of constant intensity and duration.

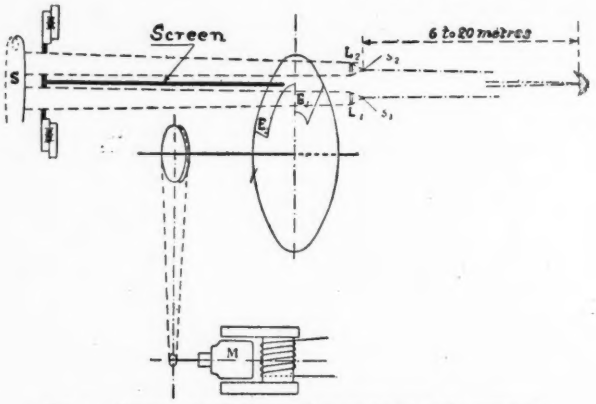


FIG. 1.—Diagram showing general principle of Rey's apparatus.

The other crank E_2 passes in front of the lens L_2, and causes a flash of a duration varying with the width of the crank, and of an intensity equally varying according to the length of the filament utilized. The cranks are so placed that the two flashes are simultaneous.

The principle of the method of measuring is the following :—

The observer compares the two flashes by, firstly, drawing sufficiently near to the apparatus to see them appear distinctly, and then moving away until he sees only one appear. From his indication the operator modifies the intensity of the source S_2, and the observer begins over again. On further instructions from him the source S_2 is again modified until the two flashes disappear simultaneously at the same distance. The two flashes are then " of equal visibility," that is to say, they have the same " range limit " for the observer. At this moment the length of the filament of the source S_2 utilized is measured and noted down. Experiment has shown that under these conditions, as soon as the observer draws near, the impression of equality ceases, and *the most rapid* of the two flashes appears as the most intense.

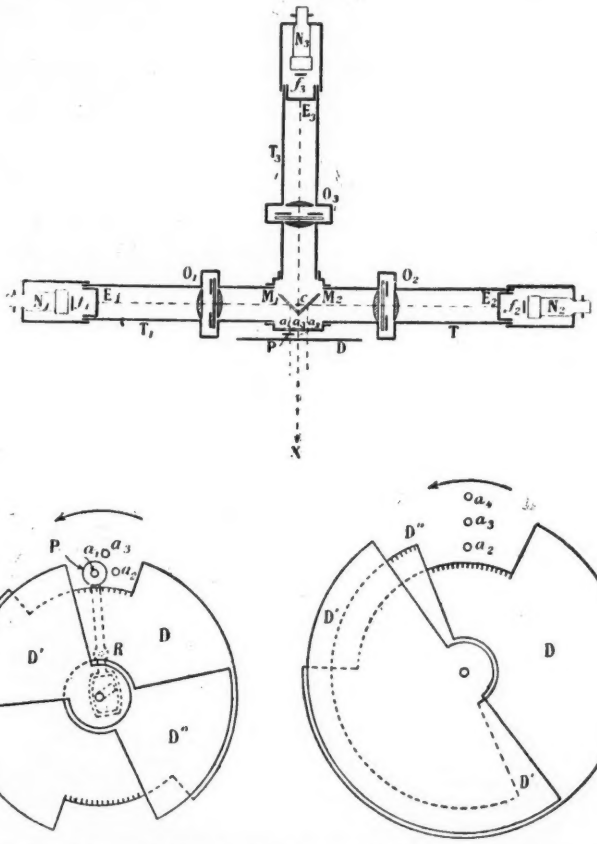
Blondel's Apparatus.—This apparatus is based upon the employment of diaphragm lenses introduced into photometry by Bouguer, then by Cornu, and which has been considerably improved upon by Blondel.* Figs. 2, 3, and 4 show a scheme of the arrangement of the apparatus.

The tube T_2 being placed a little higher than the others, the three small frosted glasses, a_1, a_2, a_3, appear

* He has substituted the former cat's eye by a special one formed by two curtains. When these curtains are in contact the aperture is closed. When they are withdrawn they expose a rectangular diaphragm, the height of which is variable, so as to allow of maximum sensibility, and also to secure the proportionality of the readings on the scale denoting the displacement of the curtains. Another improvement consisted in substituting for the simple Bouguer-Cornu lenses (which give deformed images) a system of double achromatic lenses which allow of very small focal lengths being utilized with a very slight aberration.

as shown in Fig. 3, at the corners of an equilateral triangle having a side of about 30 mm. In front of each of these frosted glasses there is placed a small diaphragm (not shown), supplied with a small hole of 1 or 2 mm. in diameter, which allows of point

eccentric which causes it to oscillate about the axis R, covers alternately the luminous screens a_1 and a_2; so that the observer sees in succession the flashes from these two luminous points. The periods in the flashes are regulated respectively by the



FIGS. 2, 3, and 4.—Showing the arrangement of Blondel's apparatus.

images being observed. The intensity of each of these luminous points can be made to vary as desired by working one of the three cat's eyes.

These three luminous points are compared by the observer when standing in the direction X at a distance of from $6\frac{1}{2}$ ft. to $19\frac{1}{2}$ ft.

An opaque disc P, controlled by an angular widths of the adjustable sectors D.

In this way the sensations caused by these intermittent flashes may be compared with that due to the fixed point a_3.

The device shown by Fig. 4 also allows of simultaneous flashes being obtained, as in Rey's apparatus.

Discussion and Method of Calculation of the Results obtained in these Experiments.

We now purpose to give a summary of these experiments, the results of which were carried out for the most part in the laboratory of the firm of Sautter, Harlé & Co. by means of the first apparatus. In this work we received the collaboration of a former student of the Polytechnic School, Mr. George Guy, who directed the observers and aided us in the calculations; additional experiments were undertaken by Prof. Blondel with the second apparatus in his own laboratory.

Measurements. — The observations comprised twenty-five series made by seventeen observers of different ages and professions—workmen, engineers, foremen, clerks, &c.

It was possible to draw a comparison between the vision of these different observers by taking as a standard in each case a measurement made by the same observer under certain definite and reproducible conditions.

It is extremely difficult to make a direct comparison of very long flashes with very short ones. To minimize this difficulty we proceeded on the method of successive comparisons. Flashes occupying only a small fraction of a second, for example, were compared with flashes of 0·03 or 0·3 of a second; those of one second were then compared with longer flashes capable of attaining three seconds. A summary of the results of the readings is given in Table I. and Fig. 5.

TABLE I.

t	(Et) Geometric Mean.	$\frac{t + 0{\cdot}21}{3{\cdot}21}$	Difference.
3·00 sec.	1	1	0
1·00	0·372	0·377	—0·005
0·30	0·1555	0·1588	—0·0033
0·10	0·1021	0·0965	+0·0056
0·03	0·0703	0·0748	—0·0045
0·01	0·0677	0·0685	—0·0008
0·003	0·0721	0·0664	+0·0057
0·001	0·0641	0·0657	—0·0016

In this curve the abscissae represent the duration of the flashes in fractions of a second; the ordinates, the value of the product Et (that is to say, the product of the intensity of illumination by its duration) divided by the value of the same product in the case when the flash lasts three seconds.*

It is most remarkable to notice that the mean values of the observations for each of the eight durations of flashes under consideration fell almost exactly on a straight line. This result does not imply exceptional precision, but is to some extent fortuitous. It is, however, interesting to have obtained such a good line for observations carried out between such wide limits; the result obtained for three seconds is not, we think, of great value, but the linear law seems to be satisfactorily verified between 0 and 1 second, that

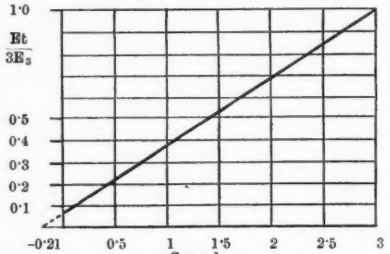


FIG. 5.

is to say, within the practical limits of use of these lights.

Numerical Expression of the Law.— The straight line in Fig. 5 shows that the product Et is a linear function of the time, $Et = A + Bt$.

We have therefore finally :—

(1) $Et = E_0\ (0{\cdot}21 + t) = E_0\ (a + t)$,

which may be written also

(2) $(E - E_0)\ t = 0{\cdot}21\ E_0$),

an equation which is of the order we had *a priori* foreseen.

A Continuous Light equivalent to a Flash Light, of somewhat greater brilliancy.—If we suppose that a permanent source is substituted for a quick flash light, and that the intensity of this permanent source is regulated so that the observer still perceives it at the same range limit as the flashing one, that is to say, without changing

* E is here expressed only in *arbitrary* units and not in *lux*. But this in no way affects the result.

position, the preceding law enables us to state what the ratio between the respective horizontal photometric intensities of the two sources must be. For let I_h be the intensity of the quick flash light and I'_h the intensity of the steady light; I_h and I'_h are proportional to E and E_0 respectively.

Then, from (1), $$\frac{I'_h}{I_h} = \frac{a+t}{t}$$

Application to Signals.

The new law is of particular interest by reason of the important applications which may be made of it in the technics of flash signals. These signals are of two kinds :—

1. — Telecommunication signals, which are intended to telegraph, in an optical form, by means of short or long flashes, the letters of the Morse alphabet.

2. — Orientation signals, by which an observer can direct his sight towards a signal light or to take the bearings of its direction.

Telecommunication Signals.—In the case of optical telegraphy signals, the source of light employed gives out a continuous flux during the whole time that it is in use; no economy of lighting is possible by reducing in a greater or lesser degree the duration of the signals*; and this duration must be chosen solely according to the best working conditions for the observers. Now, according to André Broca,† there are two limits to be observed for this kind of signal :—

First of all, a sufficient "dark period" between the successive signals (which varies from 1-100th of a second for very strong lights to 2-10ths or 3-10ths of a second for feeble lights) must be allowed between, so that the luminous sensation may become somewhat less intense before the next impulse arrives. This is necessary in order to avoid the effect of persistence of vision and to enable the signals to be distinguished.

In addition, the "light period" of the signals should be sufficient to allow of their being perceived, viz., at least 2-10ths of a second for short distances, and from 5-10ths to 6-10ths of a second for long distances.

Orientation Signals.—In the case of orientation signals, the only requirement is to increase as much as possible the *effective range* of the signals. It is precisely for this object that, instead of using a permanent light, intermittent signals are produced by using revolving searchlights or lenticular apparatus*; such lenses concentrate the total flux of the source of light into a certain number of *beams* which the rotatory movement throws upon the observer's eye. Thus they may be said to produce a subjective effect equivalent to that of an accumulator, which stores up during the period of the eclipses, the luminous flux, which would otherwise be produced in a continuous manner by the source of light, and releases it with a jerk during the period of lightness.

From a photometrical point of view, the total flux emitted by the source should not be taken into consideration, but only that part of it which is received by the pupil of the observer. This effect is estimated by multiplying the number of lux-seconds of excitation during the flash by the area of the pupil aperture on which it impinges. For example, let us suppose that the source utilized in the optic apparatus has the form of a cylinder with a diameter D and a uniform intrinsic brilliancy i†; also that the optical apparatus produces, besides the concentration of the flux into beams in the plane of the horizon, a vertical concentration proportional to the efficient height‡ of its radiant surface h.

* It would be otherwise if, for producing these signals, a metallic filament incandescent lamp which was switched on only while the signal was being sent, or a gas burner alternately lighted and extinguished, could be used, instead of the dark period being produced by obstruction of the light.

† *Annales du Conservatoire des Arts et Metiers*, Conference held on Sunday, Jan. 26, 1902.

* An invention of the illustrious Fresnel, improved by Bouedelles, who invented the instantaneous flashing device.

† These assumptions are somewhat theoretical and are not exactly complied with in practice; but they will serve to enable us to illustrate simply and precisely the methods referred to above.

‡ That is to say, the height of the exterior surfaces from which light is radiated.

If the light were uniformly distributed around the horizon, the apparatus would produce a horizontal mean photometric intensity.

$$I_{mh}=khDi.$$

The illumination received on the pupil of the observer would be represented by a corresponding expression :—

$$(4) \qquad E_{mh}=I_{mh}f(x)=kh\ IDif(x).$$

Here k is a fractional co-efficient representing the losses sustained by the rays when passing through the apparatus; x represents the distance from the observer, and $f(x)$ the function of diminution caused by the distance. This function takes theoretically the form of

$$\frac{b^x}{x^2},$$

where b denotes the co-efficient of the transparency of the atmosphere.

On the other hand, the concentration produced in the horizontal plane by the optical apparatus, resulting in the production of a flash at certain intervals, for instance, at every T second only, the "quantity of illumination"* L received by the pupil during the flash is the result of the accumulation during T seconds, and is expressed thus :—

$$(5) \qquad L=E_{mh}T=khDiTf\ (x).$$

This quantity is proportional to the excitation of the retina, and can be taken as a measure of quantity. In consequence of the ease with which the construction and the rotatory speed of the apparatus can be varied, one is able to alter within wide limits the *time* during which the beam passes in front of the pupil, whilst always maintaining the same interval* between the two signals. Attributing to each of them a number of lux-seconds E_t constant, and assuming the beam to be homogeneous, it is easily shown† that the period of the flash t is expressible as a function of the interval of the flashes T, the diameter of the source D, the focal length of the optical apparatus R, and of the number of beams of the latter, thus :—

$$(6) \qquad t=\frac{n\,T\,D}{2\pi R}$$

* In photometry "quantity of light" is called the product of the luminous flux by the time during which it is received. In the same manner we shall call "quantity of illumination" the product of the illumination by the time.

* Experience has shown that, in order to take the bearings of the point whence the signals are emitted, the observer must not turn away his eyes, and that this result can be attained only if the interval between the flashes remains less than five seconds. It would be desirable not to exceed two or three seconds, and this is facilitated by means of certain groupings of flashes.

† Cf. Blondel, *International Maritime Congress*, 1893, p. 46.

(*To be concluded.*)

Bad Lighting Increases Cost of Production.

"In one of the large silk mills of the East, it is figured by a well-known cost expert that the expense of producing their product at night is twenty per cent higher than that of producing it in the daytime. This may have been due to several things, but must be largely attributed to inferior illumination. Had these people in their factory had an illumination during the dark which was as good for working purposes as the best daylight, their cost of production during that time would very evidently have been largely decreased." — F. B. Allen, in *The Electrical Review* (N.Y.), Aug. 12th, 1911.

The Iron and Steel Institute—Autumn Meeting.

We are informed that circumstances have arisen which have led to the abandonment of the arrangements made to hold the Autumn Meeting of the Iron and Steel Institute in Turin. The meeting will therefore be held (by kind permission) at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday, October 5th, at 10.30 A.M.

The Effect of Frequent Switching Off and On of Metallic Filament Lamps on their Efficiency and Life.*

By Prof. E. W. Marchant, D.Sc., and W. Parry, B.Eng.

Introduction.—These tests were made with the object of determining whether switching had any effect on the life of lamp filaments. [The life referred to here is the time for which the lamp burns before the filament breaks. In practically every case the filament broke before the candle-power fell to 80 per cent of its initial value.] It was thought possible that the high temperature at which the filament burns, and the consequent contraction and expansion of the thread which ensues when the lamp is switched off and on, might be expected to have a considerable influence on its mechanical strength, and cause it to break sooner than if the lamp were burnt continuously under the same conditions.

Description of Apparatus. — The lamps under test were placed in holders fixed to a circular wood frame about 5 ft. in diameter. This frame was so placed in a light-tight chamber at the end of the optical bench that any individual lamp could, by rotating the frame, be brought opposite a small window on the axis of the bench in the wall of the chamber. A metal screen could be slid round this lamp to prevent light from any of the other lamps coming through the window on to the bench. Connexion was made to each lamp by means of mercury cups on the frame, so arranged that an ammeter and resistance could be inserted in the lamp circuit at time of testing, without breaking the circuit. A full description of the frame was given in the *Proceedings* of the Institution of Electrical Engineers, Vol. XXXVIII., p. 355.

Each lamp was tested initially at 230 volts, and, if necessary, manganin wire resistance was inserted, so that, on a 230 volt circuit, the initial efficiency was 0·71 c.-p. per watt (1·4 watts per c.-p.), and each subsequent test was made with the voltage across the lamp terminals equal to the initial voltage.

During their life, however, the total terminal voltage, *i.e.*, volts across lamp plus resistance, was the voltage of the public supply mains which, nominally 230, was generally more, occasionally being as high as 246. Thus the lamps were subjected to the same conditions as regards voltage variation as when in ordinary use.

The lamps were divided into two batches. The first were burnt continuously and never switched off (except on two or three occasions when alterations in the connexions had to be made). The second batch were switched out about once every minute for 10 seconds, a time thought to be sufficient to allow the filament to cool down to a fairly low temperature. The switching was effected by a contact-piece dipping in a mercury cup—the surface of the

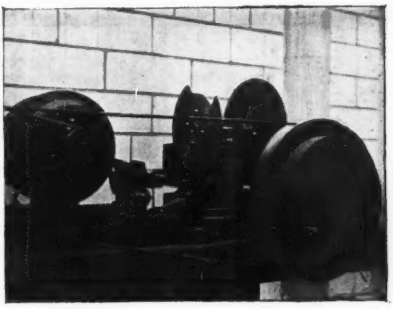


Fig. 1.—Arrangement of Switching Apparatus.

* These experiments were briefly referred to in the paper by one of the authors before the Illuminating Engineering Society on Dec. 9th, 1910 (*Illum. Eng.*, Lond., Jan., 1911, p. 29), but had not been completed in time for inclusion in this paper.

mercury being covered with paraffin oil, and the contact operated by a large cam on a spindle which was rotated at 1 revolution per minute through suitable worm and double-reduction belt gearing from a small 230-volt fan motor. (See Fig. 1.) The number of switchings was determined by a revolution counter operated from the shaft carrying the cam.

The lamps were tested on a bench of 300 cm., being compared during the first part of the tests with a 10 c.-p. standard Pentane lamp. Latterly a 25 c.-p. Osram lamp was used as a standard after it had been "aged" and carefully calibrated against the Pentane lamp. The photometer used was of the standard Lummer-Brodhun pattern. Owing to the light being of the same colour as that of the lamps under test, an exact balance of illumination in the Lummer-Brodhun photometer could be found much more quickly when the Osram lamp secondary standard was used.

Before dealing specifically with the effect of switching on life, there are one or two points of interest in connexion with the curves.

In both groups the candle-power varies over a much smaller range than it does in tests on metallic filament lamps that have hitherto been published. Amrine and Guell* give results showing a variation over a range of 20 per cent to 30 per cent of the initial candle-power. None of the lamps in these tests showed a greater range than 15 per cent, and the average was 6 per cent in both groups. In most cases there was an initial rise in candle-power up to about 400 hours, then a very gradual fall. At 2,000 hours the average candle-power was 3 per cent above the initial value. This remarkably small decrease seems to show that considerable improvements have been made in the manufacture of metallic filament lamps.

Average curves of variation in candle-power are given in Fig. 2.

The most notable thing about these lamps is the remarkable constancy of the watt consumption. In one lamp, for example, which burnt for 4,600 hours, the watt consumption varied between 49·7 and 52·8. The changes were more or less irregular, the initial reading for the watts being 50·6, and the final reading 50. Except where the filaments crossed so as to short-circuit part of the thread, the variation in the watt consumption throughout life varied in no case by more than 8 per cent. In more than half of the lamps the variation in watt consumption was less than 5 per cent, although in several cases the lamp lasted over 2,000 hours.

It was not possible to distinguish between the life curves obtained when

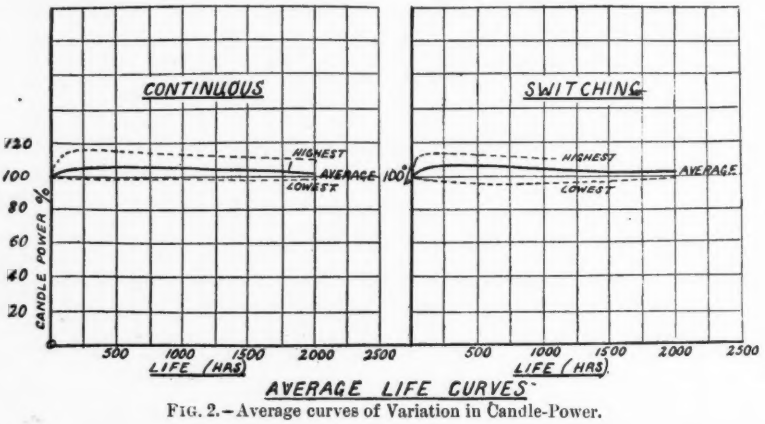


FIG. 2.—Average curves of Variation in Candle-Power.

* *Elec. World*, vol. lv., p. 69·, March 17th, 1910.

the lamps were burning continuously and those found when the lamps were switched off and on. No two life curves were precisely similar to each other, although the lamps were burnt under precisely similar conditions, but the variations in the curves obtained from different lamps burning continuously were as great as those found between "continuously burning" lamps and "switched" lamps. Typical life curves for lamps, burning continuously and when switched off and on, are shown in Figs. 3 and 4.

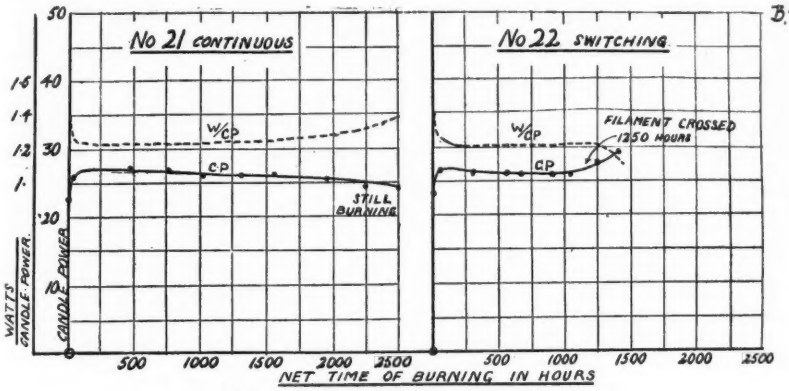


FIG. 3.—Life Curves of Individual Lamps.

(curves for which are shown in Fig. 3) the time of burning was 1,250 hours, and the number of switchings to which the lamp was subjected was over 83,000.

In the case of lamp No. 32 (Fig. 4) the filament was unbroken after 1,500 hours, and the number of switchings to which it was subjected was over 91,000.

Some of the continuously burning lamps were unbroken after 3,000 hours, and of the "switched" lamps some were unbroken after 1,500 hours' burning. One lamp has burnt for 2,400 hours

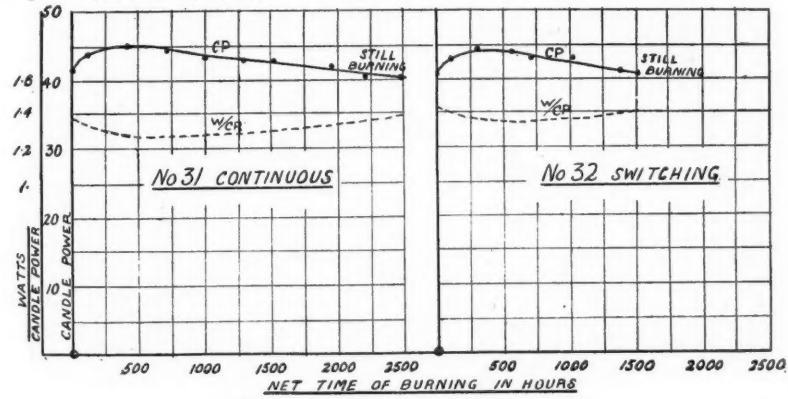


FIG. 4.—Life Curves of Individual Lamps.

In the first of these cases the time of burning before the filament broke was much less when the lamp was switched on and off. In the case of lamp No. 22 on the switching circuit. The average lives of those lamps that have given out are about 1,500 and 1,000 respectively on the two circuits. The life has

been reckoned in every case as the time for which the lamp burnt before the filament broke or was first observed to cross. The life in the case of the "switched" lamps is the *net* time of burning.

Several lamps intended for series burning (*i.e.*, two 115-volt lamps were burnt in series) were also tested, but the results obtained were not satisfactory. The life of these lamps was too short, and the variations too great, to enable comparisons to be made.

The number of lamps tested is not sufficient to enable an exact numerical average change in life to be given, but if we assume 1,500 hours as the average life for continuously burning lamps, and 1,000 hours as the life under the conditions of these tests, 72,000 switchings reduce the life by 33 per cent. It seems reasonable to suppose that the disintegrating effect is cumulative and proportional to the number of switchings. In practice a lamp burning 1,000 hours might be switched off, say, once per hour, *i.e.*, 1,000 times, hence the percentage reduction in life due to switching would be, according to the above approximate estimate,

$$= 33 \times \frac{1000}{72000} = \cdot 462$$

i.e., less than $\frac{1}{2}$ per cent.

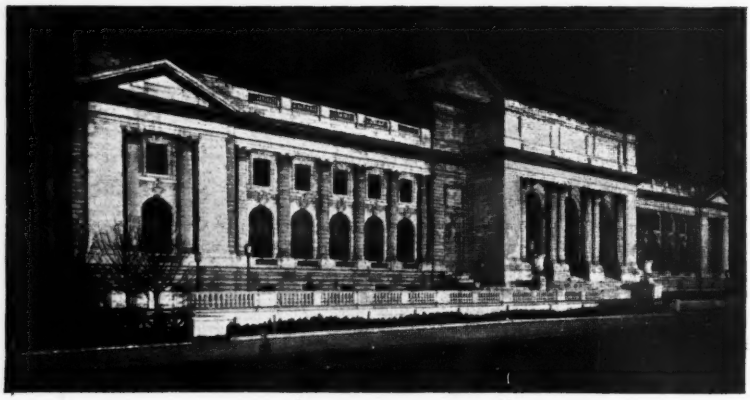
These tests, then, show that *in practice the effect of switching is negligible.*

When the great variation in temperature and the consequent extension and contraction of the filament which occurs during switching is remembered, the small effect it produces is remarkable, and brings out the good mechanical qualities of the material (Tungsten) of which these filaments are made.

We wish to express our indebtedness to the following firms for having given samples of their lamps with which to carry out the tests: The British Thomson Houston Co., Wultun Electric Co., Messrs. Edison & Swan, and Messrs. G. M. Boddy & Co.

A Striking Example of Artificial Illumination.

THE accompanying illustration, which we reproduce from the American *Illuminating Engineer*, is a striking example of the night illumination of a public building. It shows the front of a new public library erected in Fifth Avenue, New York. The light-coloured surface of the building, when illuminated by the lamps on the opposite side of the Avenue, presents a beautiful appearance, and the total absence of glare from sources of light in the immediate neighbourhood serves to accentuate the architectural details. The photograph recalls in some respects the view of the National Gallery (London) taken at night, which we reproduced in the June number.



The International Electrotechnical Commission.

THE fourth meeting of the International Electrotechnical Commission, held at Turin in September, was noteworthy both for the amount of useful work accomplished and for its truly international character, no fewer than twenty-one countries being represented by official delegates. The Illuminating Engineering Society, it may be mentioned, was represented by its President, Prof. S. P. Thompson, and its Hon. Secretary, Mr. Leon Gaster.

The proceedings were opened on behalf of the Italian Government by His Excellency the Minister of Posts and Telegraphs, Sig. Avv. T. Calissano.

Prof. Elihu Thomson, the Hon. President of the Commission, after the formal proceedings of the opening were concluded, delivered an inspiring address, in the course of which he referred to the wonderful genius of the country in which they were meeting. In the special field of science which they represented one naturally recalled such great names as Galvani, Volta, Pacinotti, and Ferraris, and it was fitting that the exhibition now being held in celebration of fifty years of national unity should be the centre for several congresses, which would demonstrate the advances that had been made in electrical science and the influence that this was having on the commercial prosperity of nations.

Prof. Thomson, in his address, referred to the valuable work done at the last (unofficial) meeting held in Brussels in 1910, and pointed out that, although in much of the preparatory work it had been necessary to proceed somewhat slowly and with due regard to the wishes of the various countries represented, some really important points had now been established. In order to deal more effectively with the large variety of subjects which they had before them, he suggested that small international committees might be formed to report on these through the central office. The subject of nomenclature in illumination was one in which they might have the benefit of the co-operation of the Illuminating Engineering Societies in England and America, and he was glad to welcome the Hon. Secretary of the London Society, Mr. L. Gaster, who had been specially invited to be present.

Following the President's address, Col. R. E. Crompton briefly sketched the progress of the Commission since its inception, emphasizing the development which had taken place in the international representation on the Commission.

At the official meeting on September 11th a number of resolutions were passed approving the recommendations of the various special committees.

Nomenclature.—An amended list of terms and definitions was provisionally adopted, based on that prepared by the Committee at Cologne and revised at a meeting held in Turin.

Symbols.—The proposals of the unofficial conference held at Brussels in 1910 were provisionally adopted with some modifications. The suggestion to use the letters I, E, and R to represent current, electromotive force and resistance respectively, was adopted, Germany making a concession with regard to using R for resistance instead of W, and Great Britain agreeing to drop C for current in favour of I.

A special committee consisting of one member from each of the more important countries represented was formed to carry on the work in connexion with international symbols.

Co-operation on matters connected with Illumination.—Subsequently the Hon. Secretary of the Illuminating Engineering Society (Mr. L. Gaster) suggested that the Commission might study the question of nomenclature in illumination, and thought it desirable that the national committees should co-operate with the Illuminating Engineering Societies in their respective countries in this matter (as had been suggested by the President in his address). The suggestion received warm support from Prof. A. E. Kenelly and Dr. C. H. Sharp on behalf of the American Illuminating

Engineering Society, and a resolution embodying this proposal was unanimously accepted.

Rating of Electrical Machinery and Apparatus.—The propositions of the unofficial conference held at Brussels were adopted without modification, viz., that the output of electrical generators be defined as the electrical power available at the terminals, the output of electrical motors be defined as the mechanical power available at the shaft, and that both these quantities be expressed in international watts.

A special committee was also formed to continue the work in this department, and it was suggested that the various national committees should co-operate with the Technical Societies in their respective countries in order to forward the work.

Future Meetings of the Commission.—It was decided that the next official meeting should be held in Berlin in 1913, and an invitation from the President of the American Institute of Electrical Engineers, Mr. Gano Dunn, to hold a meeting in San Francisco in 1915, on the occasion of the Panama Pacific Exposition, was accepted, the central office being instructed to co-operate with the American Institution of Electrical Engineers in the organization of an international electrical congress at the same time.

It may be mentioned here that at a meeting of the International Electrical Congress held in Turin two days later, the desire was expressed that future congresses should be arranged by the International Electrotechnical Commission to take place simultaneously with the meetings of the Commission, the exact date and locality being fixed by the latter. Seeing that the Congresses will in future be organized by the Electrotechnical Commission it should be possible to make arrangements for this to be done, and an encouraging precedent has been set by the success of the double meeting this year in Turin.

Among the official delegates of the different countries who were present on this occasion may be mentioned: Mr. Alexander Siemens, Prof. Silvanus P. Thompson, and Major W. A. J. O'Meara (Great Britain); Mr. Gano Dunn (President of the American Institute of Electrical Engineers), Mr. C. O. Mailloux (U.S.A.), Dr. E. Budde (Germany), Mr. F. H. Mears (Government of India), MM. P. Boucherot, R. V. Picou, and F. Laporte (France), E. Gerrard and O. de Bast (Belgium), Prof. Gill (Canada), Prof. Larsen (Denmark), Don Luis de la Pena (Spain), Prof. Feldmann (Holland), M. de Chatelain (Russia), Prof. J. Landry (Switzerland), Mr. C. A. Rossander (Sweden), Mr. A. Costello (Mexico), Dr. A. Oya (Japan), Mr. J. Muller (Equador), &c.

In conclusion, special acknowledgment should be made of the indebtedness of the Commission to Prof. Luigi Lombardi, President of the Italian Institution of Electrical Engineers, who kindly presided over the preliminary meetings, to Col. R. E. Crompton, the Hon. Secretary, and to the indefatigable General Secretary, Mr. C. le Maistre.

ILLUMINATION AT THE INTERNATIONAL ELECTRICAL CONGRESS.

At the International Electrical Congress in Turin, to which we are obliged to refer somewhat briefly in this number, illumination was also assigned an important position. The paper read by Mr. Leon Gaster on 'The International Outlook in Scientific Illumination' commences on the next page. At the conclusion of the paper Mr. Gaster exhibited the Holophane Lumeter instrument for measuring illumination, and Dr. Clayton Sharp also showed his well-known illumination photometer.

On the proposition of Mr. Gaster the following important resolution was put to the meeting and carried unanimously:—

This Congress deems it desirable that an International Commission should be nominated in order to study all systems of lighting and technical problems connected therewith; and, having been informed that the Illuminating Engineering Society of London has the intention of forming such a Commission, and of putting itself in touch with the other existing national and international photometric Committees, approves their taking the initiative in this respect.

The International Outlook in Scientific Illumination.

By Leon Gaster.

Delegate of the Illuminating Engineering Society (London).

(Abstract of Paper read at the International Congress of Applied Electricity, Turin, September, 1911.)

During the last few years there have been remarkable developments in different forms of electric illuminants and to-day there is a great variety of lamps available, whereas but a few years ago the choice was strictly limited. But the progress that has been made in connexion with the *use* of light, in addition to improvements in the actual illuminants has been quite as rapid. This movement has not been confined to any one nation. Instances can be quoted of important steps taken in most of the chief countries of Europe and in the United States, and the illuminating engineering movement is really an international one.

It is therefore very important that common and accepted methods of comparing the merits of different systems of lighting not only as regards cost, but also from the standpoint of intensity, distribution of light, colour, hygienic effect, &c., should be adopted in different countries. There are also many practical problems, such as the best methods of measuring illumination, the amount of light required for various industrial purposes, &c., on which international agreement would be very valuable.

As an illustration reference may be made to the impression created in the past that "electric light is bad for the eyes"; yet it would appear that it is the *misuse* of lamps (*e.g.*, the placing of clear bulb lamps in the direct range of view and close to the eyes) that is the real cause of inconvenience of this kind. It is obviously to the interest both of the public and of those in the lighting industry that points like this should be made clear.

In the same way the statement that this or the other illuminant approaches nearest to daylight in colour needs examination. Convenient and scientific methods of testing this point are needed. The value of securing artificial illumination almost identical with daylight, for colour-matching, is now appreciated and a number of efforts have been made (by the combination of various lamps and by the use of specially designed screens) to change the colour of the light from arclamps and metallic filament lamps so as to comply with this requirement.* Naturally this may involve a loss in the actual luminous efficiency, but this is often more than compensated for in correct colour revelation.

Again it is not so much the light given by the individual lamps that concerns us as the illumination produced by the system as a whole. One would therefore like to see more comparisons instituted on the basis of illumination provided, and this has been recommended in the recently issued report of the Photometric Committee of the Verband deutscher Elektrotechniker.†

International Aspects of Illumination.

The study of practical lighting problems and illumination led to the development of the Illuminating Engineering Society in the United States in 1906. This Society has made great progress, and has now over 1,500 members. Another important step taken by this Society was the organization of an unique series of lectures, delivered by authorities on their respective subjects, which took place after the last Convention at Baltimore

* See for example, Ives and Luckiesh, *Illum. Eng.*, Lond., July, 1911.

† *Illum. Eng.*, Lond., vol. iii., 1910, p. 403.

in 1910. In this course not only was the development of gas, electric, oil, acetylene, and other methods of lighting treated in an impartial manner, but such problems as the physiological, and architectural aspects of illumination, the practical measurement of light and illumination, and the commercial aspects of illuminating engineering were also included. Courses of instruction on these subjects are now being introduced in several colleges and institutions in London.

The Illuminating Engineering Society in Great Britain was founded in 1909, Prof. S. P. Thompson, D.Sc., F.R.S., being its first President. An important feature of the Society is its international connexion nearly all the great authorities on lighting matters on the Continent and in the United States having given their support as corresponding members. During the last Session the Society has occupied itself with such matters as school- and library-lighting, has received the co-operation of other societies specially interested in these matters, and, with their aid, has appointed joint committees to carry on the work engendered at these discussions.

Lighting of Factories, &c.

Another aspect of lighting that has been prominently before the public notice is the lighting of workshops and factories. The Illuminating Engineering Society was represented at the second Congrès International des Maladies Professionnelles held in Brussels under the patronage of the Belgian Government last year. At this important congress over 600 delegates, many of them representing their respective Governments, were present, and a number of important papers were read dealing with the lighting of workshops and factories. In summing up the conclusions of the meeting the Congress laid special stress on the need for the adequate illumination of dangerous machinery; poor illumination was recognized as a frequent cause of accidents. This same view has been taken by the Departmental Committee on Accidents in Factories and Workshops (appointed in Great Britain) which has just issued its report. After instancing many cases in which imperfect illumination has led to fatalities and casualties, the report concludes by recommending that "inspectors should be given general statutory powers to require adequate lighting in all places where work is done and in all places which are a source of danger by reason of insufficient lighting."

It may be added that the Home Office in Great Britain have, in their recent reports, made the lighting of workshops the subject of special comment. What is, however, one of the most important steps yet taken in this direction is that just decided upon by the French Government which has appointed a Committee, composed of prominent oculists, gas and electrical engineers, inspectors of factories, &c. This Committee will study the industrial requirements in illumination, and endeavour to agree upon an adequate standard of lighting for different purposes. It will also study the best methods of measuring light and illumination, and the effects of poor lighting in leading to defects of vision, and the hygienic aspects of lighting generally.

Progress in Street Lighting.

Another matter which has been the subject of much discussion in various countries is street lighting. Great Britain and the United States have both recently sent deputations to the Continent to study the methods in use, and in England a joint committee receiving the support of members of the Institutions of Gas and Electrical Engineers, the Illuminating Engineering Society, and the Association of Municipal and County Engineers is considering the drafting of a standard specification on street lighting.

All these are examples of efforts towards putting illumination on a more scientific basis. The work in this direction is largely the result of improvements recently made in methods of measuring illumination. We have now a variety of instruments adapted for this purpose, and although it may be expected that yet greater progress will be made shortly, the measurement

of illumination may now be said to have reached a thoroughly practicable stage. It would, however, be desirable at this point to have a clearly laid down basis as to the best method of making such measurements so that, in the present attempts in different countries to collect data on lighting, the same methods will be pursued by different investigators, and results obtained which which are comparable one with another.

Another movement in the same direction which has received very influential support is the National Association for the Conservation of Vision recently formed in the United States. Experiments will be conducted with the object of studying defects in vision, and their relation with the conditions of illumination provided. A feature of the researches is the co-operation of medical authorities and oculists with photometric experts, lighting engineers, and representatives of great industrial associations interested in the welfare of employees.

International Agreement on Symbols, &c., Needed.

For the same reason it is also desirable that common units, symbols, and definitions should be employed as far as possible. A great step has recently been taken in the agreement upon a common unit between England, France, and the United States; this unit is connected with that based on the Hefner lamp, and used in Germany, Switzerland, and Austria-Hungary, by a simple relation (1 Hefner candle=0·9 International candle). We may hope that the time is not far distant when one and the same unit will be employed by all civilized countries.

But besides agreement on this point it is also essential that some complete understanding should be arrived at as to methods of testing and expressing candle-power. In some cases mean spherical candle-power is determined, in others mean hemispherical candle-power, and in others merely the light in some specified direction. The lack of some common practice in this respect has often proved inconvenient in comparing electrical illuminants of different kinds, and Prof. H. Strache* has pointed out that similar uncertainty is apt to be met with in the case of gas lamps, especially in comparing lamps carrying upright mantles with those using the inverted type. Another point that should be made clear is the part played by reflectors in increasing the light in certain directions. Naturally the lower mean hemispherical candle-power, for example, may be altered considerably by the reflecting powers of such accessories. If in some cases lamps are tested with globes and reflectors in position, and in other instances without such apparatus much uncertainty is apt to occur in drawing any comparison between them. It may also be recommended that, whenever possible, the polar curve of light distribution of the lamps should be determined.

In any case, whatever method of testing is employed, authorities are agreed that it should be clearly stated whether mean spherical, or hemispherical, or candle-power in some specified direction is intended. It has become customary among many authorities to denote this by means of an appropriate prefix attached to the symbol (for example :—

I_c denotes Mean Spherical C.-P.
$I_{\bar{0}}$,, Mean Lower Hem. C.-P.
$I_{\bar{0}}$,, Mean Upper Hem. C.-P.
I_h ,, Mean Horizontal C.-P.

A list of such symbols received the approval of the International Photometric Commission in 1907, and has also been accepted by both the Verband deutscher Elektrotechniker and the Verein von Gas und Wasser-fachmännern in Germany, but they do not seem to be yet sufficiently known and widely used in all countries.

There is also much room for improvement in simplifying the large number of units of illumination used in different countries, and in clearing up the confusion attaching to many terms such as intrinsic brilliancy, surface-brightness, &c., which are used in distinct senses by different writers.

Dr. Monasch† has tabulated the series

* *Illum. Eng.*, Lond., vol. ii., 1909. pp. 424, 439.
† *Illum. Eng.*, Lond., vol. ii., 1909, p. 742.

of units of illumination commonly used, and, although a considerable simplification has been introduced by the agreement to use a common unit of light on the part of France, Great Britain, and the United States, the list is still a very long and varied one.

It is interesting to compare the list adopted at the International Photometric Commission* with the amended series recently tentatively suggested by the Sub-Committee of the Illuminating Engineering Society in the United States† and the list of supplementary terms advocated by Prof. A. Blondel.‡ We find that there is a substantial basis of agreement, but there are still terms and symbols on which difference of opinion exists.

The question of nomenclature and symbols is a matter of consequence to the International Electrotechnical Commission, and naturally also to the Illuminating Engineering Society, which is both representative of different illuminants and international in scope. Excellent work has been done in this direction by the International Photometric Commission, which has just concluded its third meeting at Zurich. It is satisfactory to note that the Commission is amending its constitution so as to be more truly international and representative of the various illuminants concerned and it may be suggested that this body, with the co-operation of the Illuminating Engineering Societies might well become the centre of a permanent international committee to deal not only with photometry, but also with other problems in illumination of general interest. The International Photometric Commission, it may be noted, at present only meets at intervals of four years but it might well receive the co-operation of sub-committees in various countries which would be prepared to meet more frequently.

The Commission was formed originally mainly to study scientific problems of importance to the gas industry, but has gradually been led to take a more intimate interest in matters connected with photometry and illumination. Meantime other bodies, including the Illuminating Engineering Societies in Europe and America, the Institutions of Gas and Electrical Engineers in Germany, &c., have been active in attacking these problems, and have already shown a desire to come to some general understanding.

What is needed is to have some means of centralizing and collecting together the work that is being done independently by bodies at present working on different lines, and hence inevitably paving the way for future confusion. If all such efforts could be replaced by a single authoritative body, this would be a most gratifying result and I feel sure that the Illuminating Engineering Society of London, which I have the honour to represent at this Congress, would be only too happy to render assistance in this direction.

* *Illum. Eng.*, Lond., vol. i., Jan., 1908, p. 77.
† *Illum. Eng.*, Lond., vol. iii., Feb. 1911, p. 74.
‡ *Illum. Eng.*, Lond., vol. iii., May, 1911, p. 265.

Illuminating Engineering Society.

CHANGE OF ADDRESS.

We are informed that the address of Mr. W. Ferguson, which appeared in our June issue as 131, Coromandel Street, Wellington, N.Z., is now changed to 99, Hill Street, Wellington, N.Z.

The International Hygienic Exhibition at Dresden.

THE International Exhibition on Hygiene, held at Dresden this year, originated in the conference on health which took place in that city in 1903. A second congress was held in 1906, and it was then determined to arrange for an international exhibition which would bring home to the public the great progress made in matters relating to hygiene during the last few years.

The exhibition has differed essentially from the ordinary displays of this kind, the chief point being in its excellent scientific organization. There have been in the past international exhibitions in plenty, at which the industrial progress of different nations was illustrated by rows of engineering and other exhibits. Such displays have often been of considerable interest to the scientific and engineering professions, and doubtless also beneficial from the commercial standpoint. But the scientific way in which this exhibition has been laid out to interest the general public, and the pains taken to show the historical development of the subject, make it almost unique.

Modern Hygiene is a big subject. In various sections of the exhibition were to be seen examples of the latest methods of ventilation, preparing food, sanitary appliances, hygienic clothing, &c. School hygiene was also well represented. The planning of buildings and classrooms, the order of studies, children's lockers, desks—all are illustrated by working models from the Continental museums at Hanover, Copenhagen, and elsewhere. The part played by games and physical training in the modern curriculum, Swedish gymnastics, and so forth, receive also special illustration, an interesting feature being the account of the effects of athletics on the human organism.

Equally elaborate is the section dealing with dwelling-houses and domestic appliances, and the various branches of medical treatment, heat and light baths, etc. There are also special sections devoted to Colonial, Naval, and Military Hygiene.

What, however, is perhaps the most striking exhibit is in the great hall devoted to "Der Mensch." This contains a remarkable collection of information on the human body and its treatment. Innumerable models, sections, and life-sized transparencies explain the mechanism of the human body, and there is a long corridor devoted to microscopic specimens. The action of the various organs, the digestive processes, the science of feeding, and the preparation of food are all dealt with, and the common ailments of children are illustrated in the same painstaking and scientific way. There are even models showing the "rashes" characteristic of measles, &c. The diseases peculiar to certain nations, and in particular tropical diseases, are dealt with in the medical section.

The Hygiene of Occupations was also well treated, and in one building a number of modern ingenious devices were exhibited for improving the sanitary conditions of such trades as leather, fur, and bristle work, dyeing, &c. There was also statistical data and information on town-planning and the parks, gardens, hospitals, &c., to be found in many European cities.

Amid all this multiplicity of data on health, one would naturally expect to find some attention paid to illumination, and this subject receives notice in a special section. Illumination is only just beginning to gain a proper footing among the many matters considered by hygienic authorities, and we may expect that in the future the prominence given to the hygienic side of lighting will be much greater than at present.

One of the most interesting exhibits in this section was that dealing with the historical development of lamps.

We have previously remarked on the excellent displays of this kind to be seen in the museums at Munich and elsewhere, and the method followed on this occasion seems not dissimilar. Actual examples of ancient lamps, candlesticks, and tinder boxes in historical sequence are shown, even the old pinewood splinter and the crude appliances for holding it in position being displayed. In this exhibit one can trace the gradual development of illuminants, oil lamps, flat-flame burners, regenerative lamps, etc., right up to the high-pressure gas mantles and metallic filament lamps of to-day.

Various forms of modern lamps were shown by Messrs. Körting and Mathiesen, and also models showing the distribution of illumination. There were also comparative tables, showing the cost of various illuminants, the amount of heat developed for a given intensity, etc. The subject of glare was dealt with in an exhibit by Dr. Stockhausen, showing the intrinsic brilliancy of a number of flames and incandescent sources. The same exhibitor showed his well-known spectra diagrams, illustrating the amount of ultra-violet light in modern illuminants and the effect of the Euphos glass in cutting off radiation of this character. In an adjacent room there was also exhibited photometric appliances, and a complete gas-testing laboratory was shown in operation.

It will be recalled that members of the Illuminating Engineering Society were invited to exhibit, and through their agency a number of photographs, bound volumes of *The Illuminating Engineer*, &c., were loaned to the exhibition. The photographs related to various modern methods of illumination by gas and electricity, and included views of various typical gas-illuminated schools prepared by the Gas Light and Coke Co.; factories lighted by high-pressure gas (Messrs. Keith & Blackman, Ltd.) and interiors illuminated by inverted arcs (The Union Electric Co., Ltd.).

Several members of the Society, including Mr. J. Eck from this country and Dr. Stockhausen and Prof. Ulbricht in Dresden, also kindly undertook to represent the Society on this occasion.

In conclusion a word or two may be said about the lighting of the exhibition grounds. This was mainly carried out by inverted high-pressure gas lamps of the "Pharos" and other types. There were also, however, a number of high-pressure Hirschorn oil lamps, while the Congress hall was illuminated by the "Moore" light system.

Architectural Features emphasized by Special Lighting.

A NEW store in one of the principal streets of Chicago has, according to a note in *The Electrical World*, been brought into prominence among its neighbours by the use of elaborate electric lighting effects. The expense of this special external lighting is borne by the owners of the building independently of the tenants, and the whole scheme has been designed with a view to striking publicity.

The entire front of the building is of glazed white terra cotta, and this surface has been illuminated partly by an inverted trough just beneath the cornice, containing 290 25-watt tungsten lamps spaced 1 ft. apart, and partly by massive bronze standards fixed to the division walls between each pair of store-fronts. Each of the latter has four 40-watt tungsten lamps, enclosed in 12 in. frosted spheres, and at the top similar bronze brackets are used, fitted with single 14 in. spheres. It is stated that a very high intensity of illumination is thus obtained on the surface of the building, and the architectural ornamentation has been so well emphasized that the building presents a most striking appearance after dark.

Fifth Annual Convention of the Illuminating Engineering Society (U.S.A.).

We print below a list of the papers read at the Fifth Annual Convention of the Illuminating Engineering Society (U.S.A.) held in Chicago from September 25th to 28th. An attractive programme of entertainments and visits was also arranged. Among the items of more technical interest may be mentioned the new lighting of Michigan Boulevard, the high pressure gas lamps at the People's Gas Building, and the indirect lighting equipment of some of the Michigan Avenue Hotels.

The following is a list of the interesting series of papers presented, and we hope to refer to these more fully in our next number :—

SUBJECT.	AUTHOR.
Presidential Address, 'The Relations of Physico-Physiological Research to Illuminating Engineering'	Dr. A. E. Kennelly
Report of Committee on Nomenclature and Standards	Dr. A. J. Humphries, Chairman.
Report of Committee on Progress	Dr. Louis Bell, Chairman.
Symposium on Illuminating Glassware	Bassett Jones, Jun. A. J. Marshall L. W. Young C. H. McCormack
The Manufacture of Glass for Illuminating Purposes	E. H. Bostock
An Analysis of the Requirements of Modern Reflector Design	F. L. Godinez
Recent Small Gas-Lighting Units	F. H. Gilpin
Natural Gas, its Production and Utilization	G. S. Barrows
Recent Developments in the Manufacture of Incandescent Lamps	J. E. Randall
The Law of Conservation as Applied to Illumination Calculations	Dr. A. S. McAllister
The Photometry of Large Light Sources	Geo. H. Stickney and S. L. E. Rose
The Analysis of Performance and Cost Data of Illuminants	Ward Harrison and G. H. Magdsick
Photometry at Low Intensities	Dr. Louis Bell
Evaluation of Lamp Life	P. S. Millar and L. J. Lewinson
Distribution of Luminosity in Nature	Dr. H. E. Ives and M. Luckiesh
Resumé of Legislative Enactments on Illumination	E. L. Elliott
Illumination or Equipment ?	F. B. Rae
Influence of Surroundings and Lighting Systems on the Illumination Required	J. R. Cravath

The American Association for the Conservation of Vision.

We have previously referred to this Association, recently formed in the United States to promote all the methods by which eyesight may be protected and preserved. Its scope is very wide, and in order to accomplish its purpose effectively it has been divided into six different departments, dealing respectively with diseases and defects of the eye, and the medical aspect of the question; the hygiene of eyesight in schools; the means of preservation of eyesight in factories, workshops, offices, &c., and in industry generally; statistics and information; existing legislation; and publicity arrangements.

We now notice that the first number of the *Bulletin* of the Association, besides containing a considerable amount of space devoted to a discussion of structural defects of the eye, includes a section which deals specially with the effect of poor illumination in causing eye-strain, and summarises some of the most generally admitted points with regard to choice and position of lighting fixtures, the use of proper globes and shades, &c. It is insisted upon that attention to these details must have a direct effect in preserving vision.

Another section, headed 'Accidents,' points out that blindness is frequently the result of an accident, and infers from this the necessity for more care in the provision of safe guarding devices, such, for example, as protective shields round emery wheels, &c. A variety of accidents which occur quite commonly are mentioned, and some practical advice is given to those who have to deal with them.

In addition to the *Bulletin*, which we have briefly referred to, the Association has issued the first of a series of monographs which will deal in a more detailed manner with certain aspects of vision and its conservation. The subject of this first monograph is 'The Prevalence and Prevention of Ophthalmia Neonatorum,' and is the outcome of a study of this disease in various cities of Massachusetts by the Research Department of the Boston School of Social Workers.

We note that the Association is under distinguished patronage, President Taft, Ex-President Roosevelt, and the Hon. Joseph Choate being honorary vice-presidents, among whom are also several famous lady representatives, including Miss Jane Adams and Miss Helen Keller. The acting president is Dr. F. Park Lewis, and we are also pleased to see that the Editor of the American *Illuminating Engineer* (Mr. E. Leavenworth Elliott) is the Vice-President of the Association, thus illustrating the co-operation between the illuminating engineer and the oculist in this new movement for the conservation of vision.

Luminous Tubes containing Neon.*

Readers of this journal are doubtless familiar with the Moore Tube system of lighting introduced in the United States some years ago. In this system, it will be recalled, a soft luminous glow is produced by the discharge of electricity through rarified gases in long tubes. If nitrogen is used a pinkish light appears to be obtained. With carbon dioxide, however, the light is said to be of a very white character closely approaching daylight.

Reference has also been made in this journal to the more recent attempt to utilize the rare gas neon in this way. It is remarkable, when one comes to think of it, that such gases as argon and neon were unknown but a few years ago,

* Based on a paper read by M. G. Claude, *Comptes Rendus*, 152, pp. 1377-1399, May 22, 1911.

and were isolated from the atmosphere only in minute quantities and with extreme difficulty by Sir William Ramsay. Now, however, we already hear of their practical utilization for producing light.

Some additional particulars about these new tubes have been recently published by M. George Claude, to whose experiments we have previously made reference.* The method differs in several respects from that previously employed in the United States. An ingenious feature of the Moore system is the use of a special valve. This is necessary because the gas tends to be absorbed by the electrodes so that the conditions in the tube tend to gradually change. Consequently the light would soon fail but for the fact that the valve opens periodically, it appears, about twice a minute, and allows air to enter so as to maintain the pressure in the tube constant. But this method cannot be readily applied in the case of the neon tube. The slightest trace of foreign gases seems to result in a considerable diminution in the light. Moreover the exceptionally high luminous efficiency of neon is stated to enable relatively small tubes to be used, and it would not be convenient in such cases to employ a valve of this kind.

M. Claude therefore attempted to dispense with the valve. There were several circumstances leading him to suppose that this might be possible, notably the reputed chemical inactivity of neon and its extremely small electric cohesion. An internal pressure more than ten times that permissible in the case of nitrogen may be safely used, so that there is a much greater margin for wasting of the gas.

Notwithstanding this, the first experiments were not very successful. The electrodes volatilized rapidly and the light soon went out. But by increasing the size of the electrodes much better results were secured. Copper cylinders 25mm. in diameter and 60mm. long were next used. It was then found that a tube 5m. long and 30mm. in diameter, and taking an alternating current of the order of 0·4 amps., lasted as long as 6 to 8 hours, and gave a very bright light while doing so.

It was evident, however, that the electrodes still suffered. They became red hot, and a metallic scaly deposit was formed on the tube in their neighbourhood. When analyzed this proved to contain both neon and helium.

The existence of so much helium was surprising, for there could only have been very minute traces of this gas present in the tube. Possibly, the author suggests, the metal exerts a selective preference in absorbing this gas. Another striking suggestion is that neon might undergo decomposition into helium during the process !

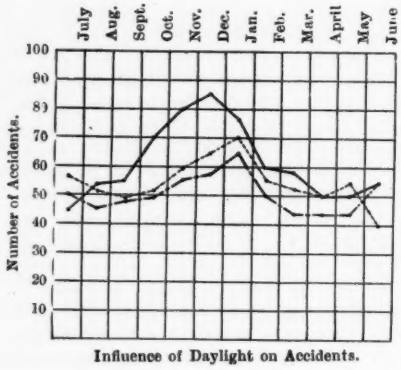
To improve the conditions the electrodes were made bigger still. In certain tubes installed at Grand Palais copper cylinders having a superficial area of 3dm² per ampere were used. These tubes were 45mm. in diameter and had the exceptional length of 35 metres. One of them operated successfully for 210 hours, and only gave way owing to an accident. Tubes of 5 and 6 metres in length have not proved quite so satisfactory. But by increasing the area of the electrodes to 5dm² per ampere the tendency to volatilization of the electrodes has been still further reduced and excellent results obtained. A tube 6m. long furnished with these larger electrodes recently yielded a life of 400 hours without any appreciable alteration in the conditions, except for a fall in P.D. of about 4 per cent.

In conclusion M. Claude suggests that it is now possible to make tubes 5m. or 6m. long which will operate quite well and can be manufactured commercially. His experiences also suggest that the possibility of avoiding the necessity for using a valve have been pretty clearly established. The efficiency of these neon tubes is said to be in the neighbourhood of 0.4 watts per candle. According to particulars which have appeared elsewhere the light seems to be of an orange red colour. It will be interesting to watch the development of this new method of illumination.

* *Illum. Eng.*, Lond., Feb., 1911, p. 115 ; July 1911, p. 432,

Illumination and Industrial Accidents.

THE accompanying diagram, which we reproduce from an article in the *Journal of Industrial Safety* for April, is of interest as showing the influence of daylight on the number of accidents which take place in factories and workshops.



Influence of Daylight on Accidents.

The chart shows the number of reported fatal accidents per month for three successive years which took place in about 700 factories out of a total of 80,000 reported upon. It will be seen at once that during the months of November, December, and January, when daylight is diminished and artificial illumination has to be resorted to for some hours each day, the number of accidents is greatly increased, this increase being quite noticeable in each of the three years.

As is pointed out in the article from which the above diagram is taken, it is probably not the intensity of the artificial lighting which is at fault—it is comparatively easy to get sufficient light; but the better placing and shading of the lamps to get more perfect diffusion must, it is suggested, be the aim for the future, so that daylight conditions may be more faithfully reproduced, and the "peak" in the accident curve may be removed.

Lectures on Illuminating Engineering at the Northampton Institute.

IN the recently issued prospectus of the Northampton Polytechnic Institute for the Session 1911–12, we note with interest that a special course of lectures on Illuminating Engineering has been arranged to be given jointly by the Electrical Engineering, Technical Chemistry, and Technical Optics departments. The subjects, dates, and lecturers, are as follows :—

January 16th, 1912.—The Nature of Light and of Radiation. By S. D. Chalmers, M.A.

January 23rd, 1912.—Photometry and the Measurement of Light. By A. C. Jolley.

January 30th and February 6th, 1912.—The Production of Electric Light and its Distribution. By F. M. Denton, A.C.G.I. (2 lectures).

February 13th, 1912.—The Chemistry of Gas Manufacture and Lighting. By S. Field, A.R.C.Sc.

February 20th, 1912.—The Use of Shades and Reflectors. By S. D. Chalmers, M.A.

February 27th, 1912.—Physiological Factors in Illumination. By W. Ettles, M.D.

March 5th, 1912.—The Practical Use of Arc Lamps.

March 12th, 1912.—The Practical Use of Metallic Filament Glow Lamps.

March 19th, 1912.—The Practical Use of Gas Lamps.

The Value of Good Illumination to Railway Companies.

THE lighting of railways has been a subject of comment in several interesting articles recently. *The Railway Gazette* (May 5th, 1911) devotes a special number to this subject, and readers of this journal who desire fuller details than space enables us to give on this occasion are referred to this issue.

One cannot but be struck by the wideness of the field open to different systems of lighting on a large modern railway. "A railway," it is pointed out, "is unique amongst large users of artificial light in that its lighting installations are scattered over the length and breadth of a wide territory; and that they vary in size from the dozen or half dozen gas lamps required at a small country station to the hundreds of electric arc and incandescent lamps necessary at a large terminus or the chief engineering shops, each of which can in itself absorb the output of a good sized power house. This explains why neither gas nor electricity is likely to have a monopoly in the near future while railway companies can make successful use of both."

GOOD ILLUMINATION ESSENTIAL TO SAFETY.

Remarking on the importance of adequate illumination, the article goes on to point out that the first consideration on every line in the United Kingdom is to secure safety both for passengers and railway servants. To take an extreme case, one could readily imagine the disastrous consequences of a sudden failure of the lights at a large railway terminus such as Liverpool Street or Waterloo. Consequently after sundown every train, every station, and every place where passengers or other persons require to go must be adequately illuminated. The very safety of the trains themselves, some travelling at high speeds, is assured by means of suitable coloured lights which indicate the positions of the signal arms.

This being so, the statement in *The Railway Gazette* that railway companies are the largest individual users of light in the country seems credible enough. That is to say, there are far more lights required to illuminate railways, such as the Midland or the London & North Western, than any other concern or town in the country, with the exception of London; it is a small railway indeed whose lighting bill does not exceed at least £50,000 per annum. So important is the question of illumination considered on modern main railways that it is becoming customary to have a special lighting department. The matter can then be very fully dealt with by special experts instead of being left to the individual inclinations of a number of separate departments.

LIGHTING OF COUNTRY RAILWAY STATIONS—SIGNAL LIGHTING.

One section of railway lighting which provides a field for such illuminants as oil, petrol-air gas and acetylene is the illumination of country stations. Here, advantage might often be taken of the newer incandescent oil systems which give a more powerful and often a steadier light than the flame oil-lamp will do. Oil lamps are still very frequently used for signal lights, a specially important development during the last few years being the introduction of burners which will remain alight without attention for 7 and 8 days; oil lighting, it is suggested, is frequently cheaper than gas or electricity would be, but any means of reducing the amount of attention required is naturally very valuable.

The intensity of the light is also a matter of consequence. Seven-day burners, it is mentioned, give from $\frac{3}{4}$ to 1 candle-power only, and it is therefore vital to have the source of light at the exact focus of the lens in front, so that the rays are concentrated and sent in the right direction: naturally the coloured glass used in signals must

be selected with care. An inferior nondescript tint appears to change with distance, and any uncertainty in this respect might constitute a grave danger. On the other hand the glasses selected, though pure in colour, should not be unduly dense so as to absorb too much light.

Signals, however, are sometimes lighted by gas or electricity. In the first case burners using two cubic feet of gas per hour are in general use; in the latter 8 candle-power electric lights. With the price of gas at 2*s.* per 1,000 cubic feet and electricity 1¾*d.* per unit the costs of these systems are said to be very similar; both however, are more costly than long burning oil lamps, the approximate figures per annum for the same light being returned as £1 for gas, 16*s.* for electricity, and 5*s.* 6*d* in the case of oil. However, the advantage of being able to light up and extinguish lamps from a distance by electricity is an important one.

Uniformity of Burners.

In referring to the lighting of large railways by gas special stress is laid on the adoption of uniformity; the lighting department should order the burners, fix them up, and maintain them in good condition. One difficulty is the variation in pressure and quality of gas in different districts. To meet this it is recommended that governors should be utilized at each station and that a standard pressure should be aimed at throughout the whole system. One single type of burner suited to this pressure can then be used, and parts are interchangeable. The question as to whether bye-passes should be provided with incandescent burners needs consideration; the author remarks that the annual cost for extra gas so burned may, in the case of a large company, amount to as much as £17,000. Where possible lighting by a torch should therefore be practised. High pressure lighting is, of course, a most valuable addition where large units are required.

As regards the merits of gas and electric lighting the author remarks that a partisan outlook among engineers is a great drawback. "To one who has had technical training with both, this seems a great pity, for there is no doubt that each of the illuminants possesses features in which it excels the other; and while gas may be desirable for use at one spot, electricity may be preferable at another."

The development of flame arcs is very beneficial when large spaces have to be illuminated. But when many lamps have to be installed the trimming is sometimes an inconvenience, and it is expected that high candle-power metallic filament lamps will prove of service especially in rather remote situations, where constant attention is inconvenient. The majority of railway companies already possess generating stations of their own, but the author considers that in general it is now cheaper to take the power from outside sources. Naturally the tubes and electrically operated railways are in a special position in this respect.

Railway Carriage Lighting.

The development of carriage lighting is really a problem in itself, and *The Railway Gazette* gives a summary of a number of electric and other systems. A very interesting summary of the developments of gas lighting for railway carriages has also been published in the *Journal of Gaslighting* (February 28th, 1911). The Pintsch system of lighting by oil gas was developed in 1880, when coal gas was commonly of about 25 to 30 candle-power and flat flame burners were in general use.

Now the requirements of carriage lighting are that each vehicle shall be illuminated as a separate unit and that each coach shall be lighted for 48 hours without replacing the supply. To do this gas must be compressed, but it was found that when coal gas is treated in this way its illuminating power was considerably decreased. Pintsch oil-gas, on the other hand, does not lose its lighting power under compression to anything like the same extent. Originally the gas was burned at a pressure of 2 inches and flat flame burners, taking one cubic foot per hour and giving about 8 candle-power each, were used; occasionally a small percentage of acetylene was added. On

many of the French railways and in the United States dissolved acetylene has also been used with success.*

But the advent of incandescent burners rendered possible the use of compressed coal gas, because under compression calorific power is not reduced nearly so much as the illuminating power would be. It is now found desirable to increase the gas pressure from 2 to 8 or even 20 inches. One of these burners using 0·6 cubic feet of gas per hour can replace two flat flame burners using 2 cubic feet per hour, and yet give more light; 30 candle-power units are now commonly used. The chief early difficulty in using mantles was the breakage, but considerable improvements in this direction have been made, and the small inverted mantles now commonly used are much more durable. It is stated that on main line trains, where there is little violent movement, modern mantles last about two months each; on local and suburban services, where there are more frequent jerks and stoppages, they require renewing about once every five weeks.

High-pressure coal gas is now coming into use on main railways. The Isle of Wight and North London Railways adopt this method, and several of the larger companies are at present giving the system a trial.

The importance of properly locating the lamps and making use of tasteful and effective forms of shades in carriage lighting need hardly be pointed out. The public now demand something more than mere rapid transport. They expect not only to travel quickly and smoothly, but to be able to amuse themselves and to read while doing so.

Good illumination, therefore, is a valuable weapon in attracting the passenger, and not to be ignored in any case where several alternative routes are at his disposal.

OTHER PROBLEMS.

There are, of course, numerous other special problems in connexion with railway lighting, to which reference must be left to another occasion. The value of illuminated signs as a means of giving information as to departure platforms, &c., to passengers, and thus saving endless questioning of employees, has already been taken advantage of by many of the leading companies; such luminous devices now form a familiar feature on the tubes and underground railways of London. From a broad standpoint, too, it is clear that people will more readily find their way to the train in a well-lighted station; dim and obscure surroundings inevitably lead to mistakes and confusion. In the same way the question of office lighting, the illumination of waiting rooms, and such special problems as the best means of illuminating time tables, should not be lost sight of. Although the lighting of our main railways has undergone a considerable improvement in late years, there is still much good work to be done by the lighting engineer.

* See *Illum. Eng.*, Lond., vol. i., 1908, p. 657.

Illumination Developments on the London and South Western Railway.

A CORRESPONDENT sends us some particulars of the methods of lighting used in some of the new offices at Waterloo Station (L. & S. W. Ry.), where Holophane reflectors and tungsten lamps have been installed. An illumination of 2·5 foot-candles over the desks has been provided, and the consumption is stated to be only 0·64 watts per square foot. Similar methods have been used with advantage in the corridors, where it is considered specially advisable to avoid the glare from a long series of unscreened lamps. Appropriate reflectors have also been used in the cloakrooms and lavatories, and in

the generating station and repair shops of the Waterloo and City Railway.

fitting in the Entrance Hall just outside the offices of the superintendent of the line. The illumination

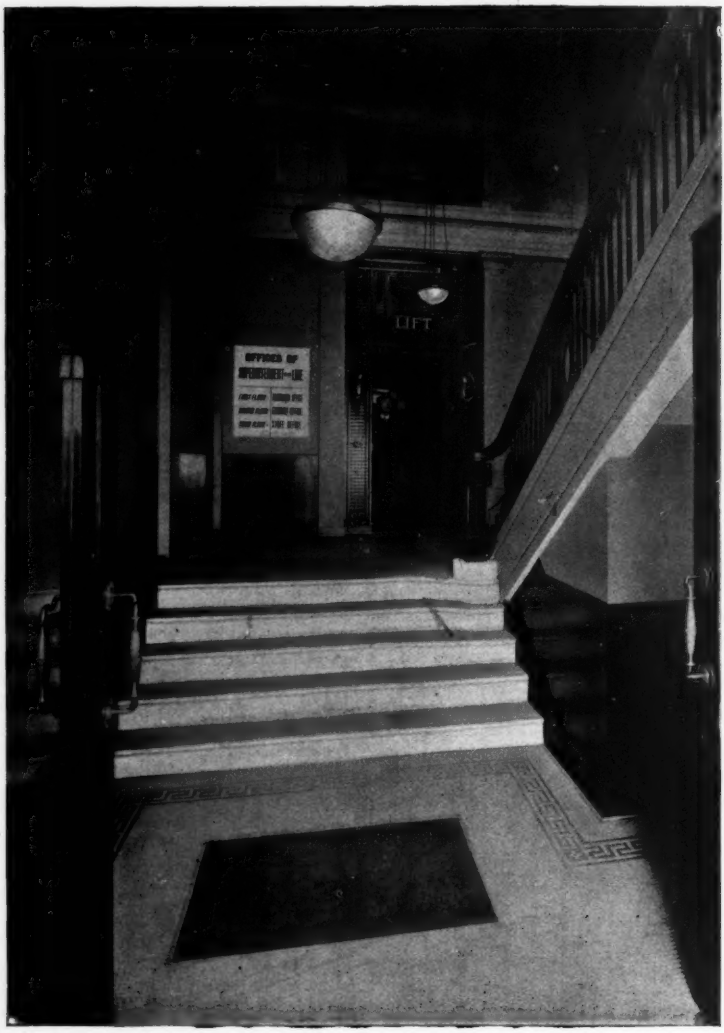


FIG. 1.
Showing Illumination by Holophane Reflector Bowls, in Entrance Hall (L. & S. W. Ry.).

The above illustration shows the use of the Holophane reflector bowl on this and other landings is in the neighbourhood of 0·5 foot-candles.

Illumination Requirements for Various Purposes.

DURING the past few years there has been a great development in instruments for the measurement of illumination. It is now a simple matter to visit any existing installation and measure, with a fair degree of accuracy, the amount of illumination produced at any particular point. The question of *how much illumination should be provided* under any given conditions—recognised to be an important one—can therefore be dealt with on a scientific basis, evidence being collected based on actual tests. It therefore occurred to us that a short article embodying some of the most recent data available as to the amount of illumination required for different purposes and under various conditions might be of interest to our readers.

In making any attempt to generalize from the results given by different authorities, it must be borne in mind at the outset that much depends on the exact local conditions. For example, in specifying a suitable illumination for a factory, it makes all the difference whether the work carried on is of a fine nature, demanding close attention, or whether the machinery is largely automatic, requiring only occasional supervision by the attendant. Consequently general figures given for factory lighting can only be considered approximate, and the same applies to many of the other problems.

DIFFERENT REQUIREMENTS IN VARIOUS COUNTRIES.

It is, however, possible that various countries may have distinctly different requirements as regards illumination.

Differences of this kind may arise in several ways. It sometimes happens, for example, that one section of lighting receives earlier and closer consideration in some countries than in others (as school-lighting probably did in Germany). Again, a country may make an exceptional advance in the prevailing standard of illumination, owing to some special circumstance, such as the growth of the Illuminating Engineering movement in the United States.

As an illustration of the contention that the order of illumination in the United States was until recently higher than in this country, it has been pointed out that the measuring instruments available in Great Britain were formerly found not to read high enough for effective use in installations in America. On the other hand, Dr. L. Bell has expressed the view that the order of street illumination in the United States was exceptionally low. These remarks, however, were made a few years ago, and would probably have to be modified to-day.

It might also be assumed that in sunny countries, where people grow accustomed to a degree of brightness in the daytime which would be quite unusual in Northern Europe, a higher order of illumination would come to be demanded. It will be recalled that some interesting data were recently given about the conditions of daylight illumination encountered in the schools in parts of Finland. One can readily conceive that the peculiar circumstances in such a region as this (where the sun is not seen at all for weeks, and in some districts even for several months) might affect the individual judgment as to what constitutes a desirable illumination, for the eyes readily adapt themselves to the prevailing brightness. Most people suffer a little when brought into contact with the more brilliant conditions prevailing at the seaside in summer, after having spent the rest of the year in town; it takes a few days for the eyes to become acclimatized. In the same way, life in the dim conditions in mines appears to have a distinct effect on the eyes of miners, while "pit ponies" have been known to spend the greater

part of their existence underground in a condition of blindness.

Another consideration which must not be overlooked is the fact that the standard of illumination has been gradually increasing during the last few years, which have witnessed such striking developments in illuminants.

Illumination in Schools.

The lighting of schools affords a good illustration of the demand for increased illumination existing at the present day. The early German investigators advocated a minimum illumination of 1 foot-candle. The average illumination on school desks obtained by various different methods of lighting, and recorded in a paper before the American Illuminating Engineering Society in June, 1907*, was 1·9 foot-candles.

As an illustration of the varying practices in different countries, it may be mentioned that at the time of publication of these results, the Munich Commission was issuing a report in which the average desk-lighting in the Technische Hochschule† was given as 6·0 foot-candles; figures published by Dr. L. Bloch about the same time furnish an average of 6·2 foot-candles.

An examination of some experiments carried out at the request of the Board of Education of New Jersey, and described by Knight and Marshall before the American Illuminating Engineering Society this year, however, revealed much higher figures than those found in 1907, a mean intensity of illumination of 3·65 foot-candles being obtained and considered desirable.

The general average value obtained from a large number of tests made in London schools, in March, 1911, was 2·5 foot-candles. In the discussion of the Illuminating Engineering Society,‡ in connexion with which the latter tests were undertaken, several important points were established. Opinion was in favour of a minimum desk illumination of 3 foot-candles, this being not much in excess of that already existing in many of the schools at which tests were carried out. Naturally for special work, such as sewing, shorthand, reading fine print or music, higher values than this may be found necessary, while blackboards, demonstration tables, etc., demand special treatment.

Street Illumination.

Illumination requirements in street lighting also show a tendency towards higher values. Haydn T. Harrison, in 1905, as a result of tests in a large number of towns in England, gave minimum illumination values as follows:—

Main thoroughfares	0·05 foot-candles.
Side streets	0·025 foot-candles.
Suburban streets	0·005 foot-candles.

In Marylebone, in 1909, he records a minimum of 0·15 foot-candles for main thoroughfares and 0·059 for side streets. In an article in this journal in 1908, the same authority also gave for important thoroughfares a minimum illumination of one-tenth of a foot-candle—a figure which is fairly well borne out by the Report on the City Lighting, by A. A. Voysey, in 1908. Very similar figures have been given by Bloch for the streets lighted by electricity and high pressure in Berlin, and also for the main thoroughfares in Budapest. It is, indeed, a matter of common knowledge that, with the advent of such illuminants as flame arcs and high-pressure gas, the standard of illumination in many streets has been vastly raised, even since the commencement of this century.

Some values for average illumination allowances in street lighting given recently by L. Crouch* are of interest as being derived partly from recommendations of authorities and partly from actual measurements of existing installations. The values are summarised in the table on p. 585.

W. C. Allen, in a recent paper on street lighting,† has given some interesting results of actual tests in various American streets of a typically busy

* B. B. Hatch, *Trans.* Amer. Illum. Eng. Soc., vol. ii., p. 363.
† *Illum. Eng.*, Lond., vol. iv., May, 1911, p. 291.
‡ *Illum. Eng.*, Lond., vol. iv., April, 1911, pp. 203-238.

* *Elec. Rev.*, Lond., vol. 68, 1911, p. 978.
† *Trans.* Amer. Illum. Eng. Soc., vol. iv., Mar., 1909, p. 105.

variety, the illuminants being of quite different types in each case, but the conditions of traffic, &c., being fairly similar.

	Foot-candles (mean).
Magnetite arc lamps ...	0·061
Series enclosed arc lamps	0·047
Incandescent gas mantle ...	0·028
Tungsten series lamps ...	0·013

Factories.

The requirements of factory lighting, as has been already suggested, vary greatly according to the class of work to be done and the nature of the material illuminated. It will be recalled that in the recommendations in Holland, based on the Royal decree of 1897, a general illumination of 10 bougie-metres (very approximately 1 foot-candle) is demanded, while for certain special trades, such as printing, knitting, engraving, jewellery work, &c., 1·5 bougie-metres is specified. The question is of great interest at the present moment, when the possibility of a standard of illumination in factories is beginning to attract the attention of authorities. The above figures might now be considered insufficient for many of these trades named, and they are probably exceeded in many well-equipped works to-day. At the Arts and Crafts School, in London, where some of these trades are taught, some data collected were as follows :—

Wood carving	30 foot-candles.
Silversmith's work	7 foot-candles.
Bookbinding	6·5 foot-candles.
Jewellery (fine work)	20 foot-candles.

In general, however, the illumination is not fixed with special reference to the work to be done, and we still await scientifically determined data as to how much light is wanted for various processes.

The following figures are given by G. H. Stickney* for the intensity of illumination met with in practice under various conditions.

	Foot-candles.
General work with drop lights.....	½-2
Machine-shop, no drops	2-4
Machine-shop, fine work.....	3-6
Warehouses and storerooms.....	1-3
Passages	½-1
Weaving	3-6
Spinning	1-4
Carding	1-3
Breaking	1-2

The question of cleanliness is important in connexion with the amount of illumination required in a factory. J. Newman, in a paper on this subject,† suggests that a general illumination of from 0·5 to 1·5 foot-candles would be sufficient in a machine-shop where general cleanliness can be maintained, but in a foundry, for example, a higher standard of general illumination would be necessary. In any case, a higher *local* illumination would be provided over benches and special tools, a suggested value for this purpose being 4 foot-candles.

Illumination Allowances for Street Lighting.

	FOOT-CANDLES.		
	Minimum.	Maximum.	Mean.
Smallest side streets	0·0085	0·85-1·28	0·13-·26 or ·34
Fairly busy streets	0·128	4·25	0·425-0·85
Main streets...	0·170-0·255	8·5-12 8	1·70

Shops.

In a paper on this subject,‡ Messrs. C. L. Law and A. J. Marshall have recently given values of illumination found in a great variety of departments in the United States. These varied from 1·9 foot-candles in a restaurant-room up to 9·3 foot-candles on the main floor devoted to general stores. (This latter figure would, however, be reduced to 5·5 foot-candles

* *Trans.* Amer. Illum. Eng. Soc., vol. vi., June, 1911, p. 485.

† *Trans.* Amer. Illum. Eng. Soc., vol. v., Dec., 1910, p. 874.

‡ *Trans.* Amer. Illum. Eng. Soc., vol. vi. Mar., 1911, p. 186.

when the normal number of lamps only were lighted). The average value for all departments works out at 3·5 foot-candles.

Libraries.

Mr. L. B. Marks, in an account of his work in connexion with the illumination of the New York City libraries,* suggests that on reading tables an illumination of about 5 foot-candles should be aimed at, whilst he considers from 1½ to 4 foot-candles sufficient for shelves. It is interesting to compare these figures with those actually measured in a number of London libraries in the course of some tests carried out for the discussion of the Illuminating Engineering Society in January, 1911.* It was found that the reading desks were in general well lighted, although the average illumination was only 3·3 foot-candles. The average value on the vertical shelves was 1·8 foot-candles; but, on account of the great extremes met with (maximum 10, minimum 0·16), the real state of affairs is not well represented by that figure, and it was felt that far greater uniformity was needed. The figure of 1½ foot-candles might, perhaps, be taken as a minimum.

General Table of Illumination Requirements.

LOCALITY.	ILLUMINATION. Monasch* (Lux)	Blocht† (Lux)	Toone‡ (Ft.-candles)	Various Sources (Ft.-candles)	Average in Ft.-candles (very approx.)
Spinning Mills	15	15-20	1½-2	—	1·5
Weaving (light colours)	25-30	25-35	1½-2	—	2·5
Weaving (dark colours)	30-40		2½-4	—	3·5
Machine Shops	30	25-35	3-4½	1	3·0
Foundry	30	—	—	3	3·0
Fine Work (mechanical)	40	35-50	5-10	—	5·5
Living Rooms:					
Drawing-Room	—	20-30	1-2	1½-2	2·0
Dining-Room	—	—		1½	1·5
Bedroom	—	—		1½	1·5
Commercial Office	30-40	35-50	2-5	4	4·0
Drawing Office	50-60	60-80	5-6	8	6·0
Concert and Entertainment Halls	40-50	35-50	2-4	2	3·5
Theatres	—	—	1-3	2	2·0
Churches	—	—	2-4	—	3·0
Printing Works	40-50	—	4-5	—	4·5
Compositors	40-50	60-80	—	8	6·0
Shops	30-50	35-50	4-4½	2½-5	4·0
Shop Windows	—	—	—	8-20	14
Restaurants	—	35-50	—	2½	4·0
Hotels:					
Small Rooms	—	10-15	—	1½	1·5
Large Rooms	—	15-20	—	2	2·0
Corridors	—	—	½-1½	0·6	1·0
Railway Cars	—	—	1-2	2	2·0
Post Office (sorting dept.)	—	—	2-4	7	4·5
Schoolrooms	—	35-50	—	2-2½	3·0
Lecture-Theatres	30-40	35-50	2-4	—	3·5
Ball Rooms	—	—	2-3	2	2·5
Libraries:					
General	—	—	1-2	—	1·5
Local	—	—	3-4	—	3·5
Reading Tables	—	—	2½-10	3½	5·0
Bookshelves	—	—	4	1½	2·5
Reading (ordinary print)	—	—	3-4	2	3·0
Streets:					
Main	—	3-6	0·1	½	0·5
Side	—	1½-3		0·1	0·15

* *Elektrische Beleuchtung*, p. 221. † *Grundzüge der Beleuchtungstechnik*, p. 132.
‡ *Electrical Review*, London, vol. 68, 1911, p. 981.

* *Illum. Eng.*, Lond., vol. i., Dec., 1908, p. 1017.

* *Illum. Eng.*, Lond., vol. iv., Feb., 1911, p. 106.

ROOMS IN PRIVATE HOUSES.

The desirable illumination for an ordinary sitting-room, say, about 12 ft. by 16 ft., has not often been recorded in the past, but some tests by J. R. Cravath, described in a paper before the American Illuminating Engineering Society,* throw some light on this particular branch of the subject. These tests were designed primarily to compare several different methods of illuminating the room, but they also serve to show what degree of light is desirable in such a case. With the brightest light, the average illumination over the room was 2·07 foot-candles, with a maximum of 5·44 and a minimum of 0·492. In the darkest case, the maximum value was only 0·436 foot-candles, the minimum, 0·132, giving an average of 0·235 foot-candles. It is pointed out in this paper that the degree of contrast between the darkest and lightest parts of a room is in general a more important consideration than the actual amount of light found in various positions. The average, maximum, or minimum values of illumination given by the author in his paper should therefore be considered as only suggestive, and requiring modification according to the decorative scheme or other special features met with in a particular case. The conditions of illumination required in a drawing, dining-room, study, etc., are essentially different.

SUMMARY OF COLLECTED DATA.

The general table of average values of illumination suggested for various purposes, which is given at the conclusion of these notes, summarises the views of these different authorities, together with data inserted from other sources. It must be insisted upon that these figures are very approximate and tentative. Some are based only on actual measurements, others partly on theoretical considerations. Some time must elapse before we have sufficient experience to state definitely what the best illumination in these various circumstances should be.

* *Trans.* Amer. Illum. Eng. Soc., vol. vi., April, 1911, p. 398.

Customers Frequent the Bright Side of a Street.

THE value of good street lighting as a means of attracting customers to a district has been referred to previously. A striking example of this attractive power is mentioned in a recent number of *The Electrical Review* (N.Y.). It is stated that in one of the principal business streets of a large Canadian city, the rental of shops on one side was over fifty per cent greater than on the other. The explanation was that a much larger number of people walked on that side of the street, which was busier and therefore more brilliantly lighted than the other. Some of the more enterprising shopkeepers on the "dark" side realised this, and proceeded to arrange a special installation for their block of shops. The new lighting attracted customers, sales increased rapidly, and the cost of the new installation was soon paid for out of the additional profits. The ultimate result was a marked improvement in the general lighting of the street.

The Value of Moving Objects in Window Display.

A DEVICE which proved very effective in attracting passers-by to the window of a shop dealing in shirts, collars, and ties, is described in the *Edison Monthly* for August. An electric fan was introduced into the window so as to blow backwards and forwards the suspended ties. The moving objects caught the eye at once, and on the first day nearly five thousand people were counted at the window in seven hours.

The Illumination of the Building of the People's Gas Light and Coke Co. (Chicago).

By the courtesy of the People's Gas Light and Coke Co., and Mr. Chas. A. Luther, the lighting engineer to the company, we are enabled to give some particulars of the lighting of the hand-

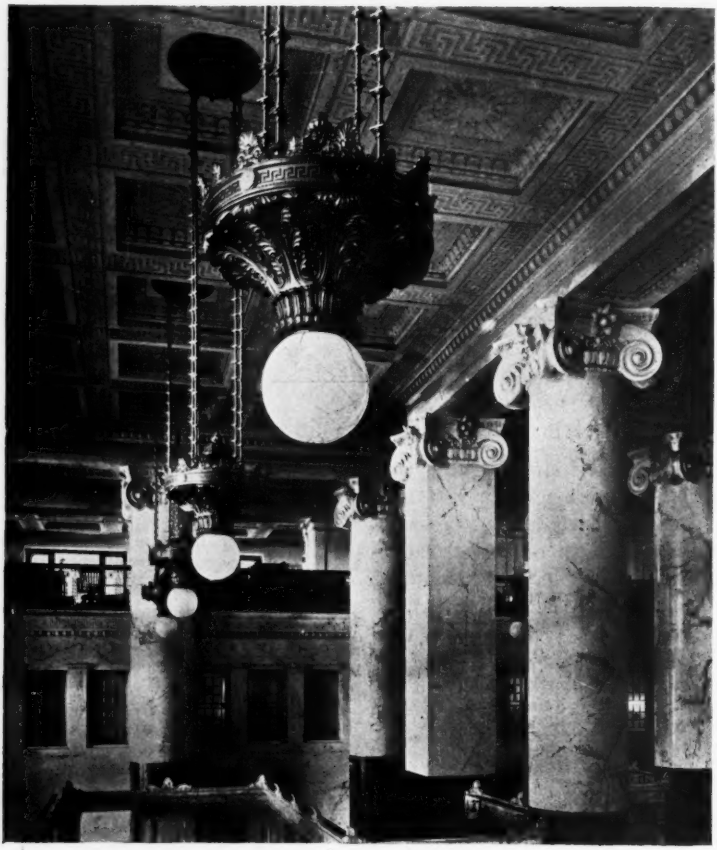


FIG. 1.—Showing Elaborate System of Decoration and Bronze Fixtures in the Building of the People's Gas Light & Coke Co. (Chicago.)

some building erected at the junction of the Michigan Boulevard and Adams Street in Chicago. The frontage facing these streets is 186 ft. and 171 ft. respectively, and the building is 270 ft. high.

Although intended primarily for the office work of the company, the design and lighting of the building are of a very ornate character. For example, the main floor, shown in the illustration facing this page, is finished in two different kinds of marble, brought

from the oldest quarries in Greece—the dark rich red "Rosso Antico" and the creamy white variety with purple veins known as Skyros marble. The ceilings are 30 ft. from the floor, and are decorated in white and gold.

The lighting fixtures are of a massive and imposing character to match this design. The solid bronze chandeliers shown in the illustration weigh 504 lbs. each, and are suspended from a very ornamental bronze ceiling plate by four bronze rods. The fixtures carry Keith one-mantle high-pressure gas lamps; these are stated to give 1,000 candle-power with a clear glass globe, but with the Alba diffusing globe used in this case they give on the average about 800 candle-power (lower mean hemispherical).

The 24 lamps of this type installed on the main floor are considered to give a very even distribution of light, so that all the details, not only of the floor area, but of the richly decorated walls and ceiling, are clearly displayed. The units are hung 18 ft. above the floor and 15 ft. apart.

By means of a special two motor compressor the gas pressure for these lamps is raised to two pounds per square inch (55 in. of water); each lamp is provided with a separate pilot flame, and, even should both the motors fail simultaneously, the lamps would still receive the ordinary city pressure. However, this is merely as a precaution, since the set is so arranged that at any time a certain part could be renewed without shutting down the high-pressure system.

The lights in the building are controlled by pneumatic means, and can be lighted and extinguished at a distance. This utilizes two separate tubes and contacts for turning the lamps on and off respectively. Thus should one of the tubes become stopped or broken, the remaining tube can be used on the ordinary suction and compression method. In the corridors there are other special ornamental fixtures, and the stairways are lighted by bronze massive standards in a similar style to the fixtures shown in the illustration. Forms of indirect and semi-indirect units are also employed.

A series of 20 high-pressure lamps are arranged among the columns at the base of the building, and throw a brilliant illumination on the pavement. They also serve to show off the features of the face of the building.

Meteorology and Lighting Bills.

Mr. W. G. Pickvance, Borough Electrical Engineer at Wrexham, describes an ingenious method of dealing with dissatisfied consumers. On examining the bills during 1910 it appeared that there were an extraordinary number of consumers whose bills for the December quarter were higher than in the corresponding quarter for 1909.

This, it appeared, was due to the inclement weather and the abnormally large number of dark, dull days. Anticipating objections to these increased bills, Mr. Pickvance hit upon the expedient of preparing beforehand printed cards, on which this explanation, based on weather conditions, was duly set out. Callers on behalf of the company were equipped with these cards, which were immediately presented to any consumer who expressed dissatisfaction. The results are stated to have been very satisfactory. The cards, however, are only issued to those consumers who are disposed to complain.

Artistic Stained Glass Lamp Shades.

AFTER a hard day's work the eyes as well as the mind crave a rest. A great glare of brilliant light is never restful.

There is no more perfect light than that produced by the shadow of a large tree on a sunny day. The soft green tones of the surroundings are harmonious and restful, but purchasers of green lamp shades should remember that

Elizabethan Design.

foliage is not transparent, and the effect of illuminated glass may be vastly different.

A lamp shade has two distinct functions—*utility* and *decoration*. It should be selected with the greatest care. A shade that looks well by day in the shop is frequently an eyesore when placed in the home. The reason for this is that glass depends wholly for its effect on the light beneath, and the shade that is designed for gas should not be used for electricity. In purchasing shades never select one until it has been illuminated by the same light you wish to use, and make sure that the sales-room is sufficiently dark to show the colours perfectly.

Positive or forceful colours should only be used with dim lighting. The colours of the best pictures are more or less subdued. Good pictures are never glaring.

The simple dome, the square and the cube forms of modern lamp shades lend themselves admirably to decoration. The dome is a conventional floral form that takes readily appropriate colouring. The Colonial shape lends itself to artistic treatment, and the Elizabethan or six-sided panelled type also provides great scope for

Colonial Design.

decorative design. Unique and odd shapes are usually poor and should be avoided.

Lamps in a room are like gems. They may flash and gleam with the light of vulgarity, or they may serve to express the culture, refinement, and proper adornment of the home.—T. VERNETTE MORSE in *Popular Electricity*.

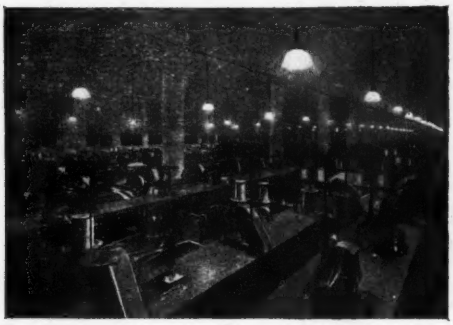
Short Notes on Illuminating Engineering.

From all Sources.

Sewing-Machines Lighted by Gas.

It has been thought that the fragility of the mantle and other causes rendered incandescent gas burners unsuitable for the lighting of factories where the vibration caused by machinery, shafting, &c., would be considerable. It appears, however, that the more modern types of gas mantle burners admit of usage under such conditions, and the illustration reproduced herewith depicts an installation of Reflex lamps for lighting the sewing-machines in a Philadelphia clothing factory.

The arrangement is such that each lamp lights four machines, and it is stated that an illumination of as much as 10 foot-candles is obtained at the needle of each machine. Although such a comparatively high value is aimed at for the local lighting, the general illumination has not been allowed to suffer, and the regular spacing of the lamps is said to give a very uniform effect.



Progress in Scientific Illumination.

Commenting on the progress in lighting since the Electrical Exhibition of 1905, a writer in *Electrical Industries* says :—

"The interval between 1905 and 1911 has, however, given us something more in connexion with incandescent lighting than the progress and perfection (*pro tem.*) of the metal filament lamp. It has given us something which would have been extremely valuable in the old carbon lamp days —the scientific diffusion and concentration of light."

Local Authorities and Public Lighting.

The question of efficient illumination is really a highly technical one, into which a great number of scientific considerations must enter; nevertheless, every lay councillor holds that he is fully entitled to give his judgment upon it by the mere evidence of his eyes and of hearsay. Thus it comes about that there is a perfect chaos of public lighting policies among local authorities.—*Electrical Industries*, Sept. 13th, 1911.

A Newel-Post Lamp.

THE design for a lamp to surmount a newel-post, which is shown in the accompanying illustration, has been put forward in a recent number of *Popular Mechanics*. It is suggested that a lantern in this style is appropriate for the present-day square

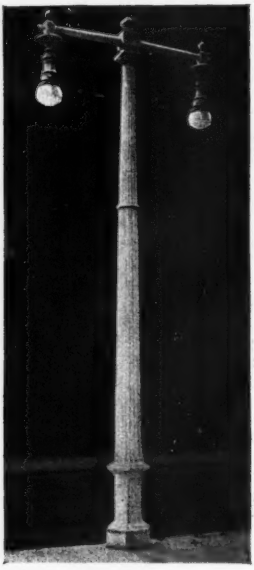
newel-post which is replacing the old turned pattern. It is of very simple construction, being made out of cardboard lined with coloured paper to form the windows. The lantern is fixed to the post by four laths of hard wood.

A Good Principle in Salesmanship.

"IN our talks with the merchant we do not talk gas light, but *illumination by gas*, and we never 'knock' our competitors. We know that we have the best illumination medium on the market, and 'knocking' only draws attention to the other fellow's goods, and perhaps causes a feeling of distrust in the merchant's mind. 'You can't saw wood with a hammer,' and the average merchant hates a 'knocker.'"—M. A. Bowlin in *The Progressive Age*, Aug. 1st, 1911.

An Ornamental Gas Lamp Post.

AN American gas company has recently installed outside its offices a row of seven ornamental lamp posts of the type illustrated herewith. Each post is fitted with two large inverted gas burners in alabaster spherical globes. The effect of the design has been enhanced by painting the posts a dead white, so that they present a striking appearance by day as well as by night.



It is pointed out in *The Progressive Age*, from which the illustration is taken, that the lamps are mainly intended to attract attention to the offices of the company. The bases of the posts have been coated with a special enamel so as to admit of their being washed frequently. In this way it has been found practicable to use white posts even in comparatively dirty surroundings.

CORRESPONDENCE.

Light and Shade in Indirect Lighting.

DEAR SIR,—I have read with considerable interest an article appearing in the August, 1911, issue of your magazine, entitled 'Light and Shade in Indirect Lighting,' by An Engineering Correspondent, which is the more interesting to me on account of the investigations I have made with the view of arriving at certain physiological, psychological, and æsthetical results, obtained under this and allied forms of lighting.

I note the experiments with the disc, sphere and statue, and, through the aid of photography and photometry, the results which have been obtained. In the table entitled 'Surface Brightness in Foot-Candles,' the disc with the inverted arc is uniformly illuminated with an intensity of 3·5 foot-candles, whereas the illumination on the sphere varies from 7·6 to 0·78. While it is probable that *perfect* uniformity of illumination would not be obtained on the sphere, no matter how it was placed in the room in which the test was made, yet it is highly probable that there would be a considerably less difference between the maximum and minimum illumination obtained on this surface if the disc were placed in the same horizontal plane instead of above the sphere, for the disc, in such position, acts, to a certain measure, as a reflector, thereby assisting in building up the maximum intensity as noted in the referred to table, which is, probably, obtained on the upper portion of the sphere. The sphere and disc should not only be placed in the same horizontal plane, but should bear the same relation to the first, secondary, and tertiary radiators.

It might also prove interesting to make actual illuminometer readings at points occupied by the disc and sphere as depicted in Fig. 3. Such test might show that there was a larger initial flux received on the disc than on the sphere. It would also appear from Figs. 2 and 3 that the room in which these observations were made had the side walls treated in some dark effect—if not black—well-nigh toward the ceiling, which would, naturally, absorb light which, otherwise, would be partially reflected to the floor and lower bases in the room, and help to build up the minimum of 0·78 obtained on the sphere. Such wall treatment would also affect the distribution of light on the statue.

Yours truly,
A. J. MARSHALL (New York).

DEAR SIR,—I thank you for your letter of the 4th inst. covering proof of Mr. A. J. Marshall's letter to you of the 11th ultimo, commenting on the experiments referred to in the article by me on 'Light and Shade in Indirect Lighting,'* cited by AN ENGINEERING CORRESPONDENT in the columns of the August issue of your Journal,† and whilst unable to agree with his deductions, appreciate most highly his interest in the matter.

Mr. Marshall does not appear, from his remarks anent the wall treatment of the room in which the experiments were made, to have had at the time of writing an opportunity of reading the full text of the original article, and has in consequence written at a disadvantage. Notwithstanding this, however, the points raised by him are of so interesting a nature that I have had the experiment of the disc and sphere repeated in accordance with his suggestions, and under, as nearly as possible the conditions prevailing in the first instance, with the result shown in the photograph enclosed under separate cover (see figure), a copy of which, together with a reprint of the original article I have to-day posted directly to him.

It will be noticed from the illustra-

* *Electrician*, June 23 and July 7, 1911.
† *Illum. Eng.*, August, 1911, p. 457.

tion that in this experiment the disc and sphere, which were placed upon the same horizontal centre and (ignoring the window surface) otherwise complied

with the conditions laid down by Mr. Marshall, have not only retained their characteristic features, but, as might have been anticipated, show under the new, and, I consider, more favourable conditions, a decidedly more pronounced difference than was apparent in the earlier experiment.

Moreover, although the shading as shown by the half tone has suffered somewhat in the reproduction, you will notice that the original photograph clearly shows the shade effect on the sphere as slightly darker on the side *adjacent* to the disc,* which is exactly what one would expect, when it is realized that in moving the sphere outwards from the vertical centre passing through the lamp, one is moving one side of it nearer to the white frieze of the two adjacent walls, and is, in consequence, deliberately creating conditions conducive to unequal lighting.

I would also add that although in the original experiment the placing of the disc above the sphere *may* have to *some* extent contributed to the building up of the maximum light upon the latter, its value, as a factor, was owing to its almost perfectly matt surface, its circular form, its position on the vertical centre of the sphere, and its low luminosity as compared with that of the ceiling, so insignificant in practice that, although with the photometer used (the Holophane Lumeter) it is possible to detect exceedingly small variations, no alteration in the surface brightness of the upper portion of the sphere could be observed when it was removed. I am, dear Sir,

Yours faithfully,

JUSTUS ECK.

* This effect is very clearly shown on the photograph from which this illustration was made, a little of the tone being naturally lost in the process of reduction.—ED.

Illumination at the Scottish National Exhibition.

By our Special Glasgow Correspondent.

In the Scottish National Exhibition —which is now enjoying a highly prosperous run at Kelvingrove Park, Glasgow—there is much of interest, both directly and indirectly, to those concerned with illuminants. The intention of the present article is twofold: first, it is desired to offer some particulars of the scheme of illuminating the grounds and buildings in the evening, and, secondly, to bring before readers some idea of the exhibits shown in the Kelvin Hall by the various firms within our own particular domain.

The scheme of illuminating the grounds and the buildings in the evening deserves special mention, and it is probable that nothing of the kind on such elaborate lines has ever been previously attempted in Scotland. When the dusk begins to descend no fewer than twenty thousand 8 c.p. electric lamps and ten thousand 2 to 3 c.p. lamps are lighted, and the illumination extends into every corner of the spacious grounds. There are a variety of imposing buildings studded over the grounds (such as the Palace of Industries, the Palace of the Fine Arts, the Palace of Music, and the Kelvin Hall, &c.), and the outlines of all these are beautifully picked out; while throughout the grounds stretch long rows of other lights. A very pretty and picturesque part, too, is to be met with at the river Kelvin, which intersects the grounds. Here the banks on either side are festooned with fairy lights, while the bridges leading across the water are similarly bedecked.

The electric lamps are of two types—8 c.p. and 2 to 3 c.p.—and none are in excess of 4 watts per candle-power, the bulbs being coloured as required. The strip used is "Pixilite" for most part, "Armorduct" being also employed in parts. The holders for the lamps on this strip were in all cases of the water-tight class. The strip was neatly affixed to the buildings by means of insulated tape. Altogether, the details of the scheme have been very well thought out, and nothing is lacking to ensure completeness.

Here it is appropriate to add that the work was carried through by a number of firms expert in this line. Messrs. Bennett & Rutherford, Glasgow, successfully carried out a large share of the work. This firm were responsible for the illumination of the Fountain Square, which carries with it the external lighting of the Palace of Music, the Palace of the Fine Arts, and the Kelvin Hall, while their handiwork is also to be seen upon the Palace of Industries, the Music Court, and the Administrative Building. Messrs. Lowden Bros., Glasgow, were entrusted with the lighting of the grounds generally and of the Amphitheatre, and great praise must be accorded them for the beautiful effects they have produced. Messrs. Malcom & Allan, Glasgow, had the illumination of the Atholl Restaurant, and this is admitted to be one of the prettiest bits in the whole scheme; Messrs. A. Hutchison, Glasgow, were responsible for the Generating Station, and the result is very creditable to them; while Messrs. James Milne & Sons, Edinburgh and Glasgow, have executed the lighting of the River Kelvin to the very best advantage. It should also be said that Messrs. Fyfe, Wilson & Co., Glasgow, have supplied to the Exhibition the whole of the underground Electric Cables for supplying electric energy to hundreds of motors throughout the Exhibition, and also for all the lighting and illumination. This comprises some 15 miles of heavy lead covered and armoured cable. The same firm also supplied the small illumination strip which has proved such a successful feature of the Exhibition Illuminations.

Coming now to the stands in the Exhibition, we may confine our atten-

tion to the Kelvin Hall, for therein are housed all the exhibits which appeal to illuminating engineers. Altogether there are over half-a-dozen stands which will repay our attention. One of the firms alluded to in our last paragraph—Messrs. Fyfe, Wilson & Co.—have an interesting exhibit of one of their 30 b.h.p. petrol driven electricity generating sets, which is capable of supplying energy for a building having about one thousand lights, and they have also a smaller 6 b.h.p. Kelvin set. These sets are very compact, and they claim a number of unique advantages. It is now some four years since the introduction of metallic filament lamps enabled this firm to place in the market these generating sets for the lighting of country houses, shooting lodges, and other buildings. They can be installed at a fraction of the cost of the old-fashioned private installation consisting of slow speed oil or gas engine and dynamo, and they have the combined advantages of compactness, simplicity, and ease of working. In designing, simplicity and reliability have been the determining factors, and there has always been kept in view the fact that the plant would probably be operated by unskilled men. The space occupied by the set, too, is reduced to a minimum, and as an instance it may be mentioned that a Kelvin plant, complete with storage cells for 150 lights, can be comfortably placed and worked in a space as small as twelve feet by thirteen.

Another exhibit of much practical interest to the world of illuminants is that wherein the well-known AEROGEN SAFETY GAS COMPANY (St. Paul's Churchyard, London)—through their Scottish agents MESSRS. MILLAR & STEWART, of Edinburgh—demonstrate the possibilities of their lighting speciality. Several designs of their patent gas-making machines are shown in operation, one being driven by a small water-wheel, one by falling weights, one by a hot-air motor, and one by electric motor. Aerogen gas is a uniform mixture of air and petrol vapour, but the percentage of the latter is very small, air being the chief constituent. The gas is non-explosive, and can only be consumed through the proper burners. It is not detrimental to the atmosphere, as it does not contain sulphur vapours and very little carbonic acid is given off during combustion.

The machine is exceptionally serviceable for country houses, schools, railway stations, &c. It requires no attention beyond keeping it clean, winding up the weights, or starting the motor and filling with petrol—a duty which occupies only a few minutes each day, and to which any unskilled person can attend—and a uniform mixture is automatically produced in sufficient quantity to feed the number of lights in use.

Not far distant we find another very important stand—that of MESSRS. GARTY, BONE & COMPANY, 61, Bishop Street, Glasgow. Two years ago this firm placed on the market their system of electric lighting of motor cars, and the results were so encouraging that they afterwards extended their system to embrace small installations for country houses, &c., suitable to be driven by oil or petrol engines, wind, or water turbines. The apparatus includes dynamo, switchboard, and battery of accumulators, the dynamo being driven from the source of power by belt, chain, or gear, the armature running on ball bearings. The system is entirely automatic, its function being to prevent the accumulator from discharging through the dynamo when under speed or when stopped. On starting, the machine commences to deliver current at about half normal speed, and gradually mounts to normal output. Above this speed the output slightly increases until about 2,000 r.p.m. is reached, when the machine reaches its maximum. The current generated goes to light lamps, and any excess recharges the battery; while, should lights not be required, the dynamo can be used to charge the accumulators or be put off altogether from the switchboard, no clutch or loose pulleys being needed. Should the speed fall below the half normal rate, or should the dynamo stop, the automatic switch comes into action cutting out the dynamo, the battery maintaining the supply of current.

At the stand occupied by MESSRS. PATERSON & SERVICE, 38, Bath Street, Glasgow, there is shown a "Pelapone" 3 b.h.p. engine direct coupled to a "Mawdsley" dynamo. The engine runs on paraffin oil, and is used for lighting the stand; about 100 lights are displayed. By using one of these combined plants, it is stated, fifty 16 c.p. lamps can be supplied at a cost of well under 1*d.* per hour. The combined plants are specially suited for country house lighting, theatre lighting, including cinematograph work, and are extensively used for agricultural purposes. This firm are also exhibiting several "Sisson" high speed steam engines, including a 100 brake horse power engine; also one 6·6 k.w. ship lighting set, the engine being direct coupled to a dynamo on the same bedplate. Many other interesting articles are shown on this stand, including a "Vulcan" reversible magnetic clutch for planing machines, "Pillow" flexible couplings, and a complete line of "Metallic" electrical accessories.

The stand occupied by the TILLEY HIGH-PRESSURE GAS SYNDICATE, LTD. (53, Kingsland Road, London, N.E.), is also of great interest. The Tilley system was invented with a view to reducing the initial cost of the compressing outfit and securing greater simplicity. This fact is well demonstrated in the Kelvin Hall display. The compressors shown are simple in construction, automatic in action, and occupy but little floor space. Further, they require no attention beyond occasional lubrication, and are thus well adapted for installation where a mechanic is not available. By means of these compressors a brilliant and absolutely steady light of great power is obtained with upright or inverted burners. The cost is claimed to be as low as one halfpenny to three farthings per hour, according to the method used.

Next we might mention the exhibit by MESSRS. THE JOHN SCOTT ENGINES, LTD., Lonend Works, Paisley, which firm is showing their well-known Gleniffer lighting plant. A special point to be noted with this system is that it is not necessary for the engine to be running when lights are required, as there is fitted a storage battery of ample capacity. To charge this battery the engine only requires to be run a few hours per week, and, as skilled attention is quite unnecessary, the upkeep and running cost are very reasonable. In addition, it is claimed that the installation is not affected by frost, and that there is no danger of gas poisoning or explosions. Special features claimed for the engine are its simplicity and accessibility, combined with durability and compactness, and it can be supplied to run on either paraffin or petrol.

This may be said to complete the Exhibition from the illuminating standpoint, and we would advise any of our readers who are contemplating a visit to Saint Mungo ere the beginning of November not to miss paying a visit to the Kelvin Hall to see for themselves the various stands which we have here attempted to describe.

Why not Standard Pressure?

"WE hailed the passing of the Standard Burners Bills with pleasure and took it as a sign of the times; but if we could only obtain, in as simple a way as the Canadian gas engineer, the universal adoption of the No. 2 Metropolitan test burner and a level candle-power standard for the whole country, the supply of constant pressure at the consumer's meters, and uniformity in the construction of incandescent burners, what an impetus it would give to the gas industry. What a tremendous advantage it would be to have unvarying pressure night and day, and burners made to give maximum results under standard supply conditions applicable to the entire industry."—*Gas*, Sept. 20th 1911.

Lectures on Illuminating Engineering at Battersea Polytechnic.

A COURSE of lectures on illuminating engineering, similar to that arranged at Regent Street Polytechnic and to which we referred in our last issue, will be delivered at Battersea Polytechnic during the coming session. The lectures and dates are as follows :—

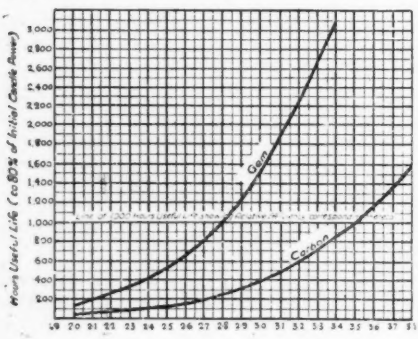
1. Tuesday, Oct. 17th.—Electric Lighting. Prof. J. T. Morris, M.I.E.E.
2. ,, Oct. 24th.—Electric Lighting. Prof. J. T. Morris, M.I.E.E.
3. ,, Oct. 31st.—Gas Lighting. Mr. J. G. Clark.
4. ,, Nov. 7th.—Gas Lighting. Mr. J. G. Clark.
5. ,, Nov. 14th.—Oil, Petrol-air Gas, Acetylene, &c. Mr. E. Scott-Snell.
6. ,, Nov. 21st.—Illumination and the Eye. Dr. W. J. Ettles, F.R.C.S.E.
7. Friday, Jan. 12th.—The Measurement of Light.
8. ,, Jan. 19th.—Illumination and its Measurement.
9. ,, Jan. 26th.—Shades and Reflectors.
10. ,, Feb. 2nd.—Daylight and Artificial Lighting Compared.
11. ,, Feb. 9th.—Colour of Artificial Illuminants.
12. ,, Feb. 16th.—Practical Lighting Problems.

Lectures 7–12 will be given by Mr. J. S. Dow, B.Sc., A.C.G.I.

The Lectures will commence at 7.30 o'clock each evening.

The Improvement of Incandescent Glow Lamp Efficiencies.

THE improvement in efficiency of incandescent glow lamps has developed in a remarkable manner by the introduction of metal filaments. It must not, however, be forgotten that there has been at the same time marked improvement in the efficiency of carbon lamps, of which the "Gem" filament is an example.



ni ial Efficiency in Watts per Candle.

The filament in this new form of carbon lamp is subjected to the intense heat of the electric furnace, which renders it capable of withstanding much higher temperatures than the ordinary filament, with a corresponding increase in the efficiency. In this way a 16 c.-p. lamp has been produced consuming only 45 watts, *i.e.*, an efficiency of 2·8 watts per candle.

In the curves which we reproduce herewith, the relation between efficiency and life is given for an ordinary carbon lamp and for the "Gem" filament. It will be clearly seen from these curves that for a given life (say 1,000 hours) the efficiency of the new lamp is a very marked improvement; or judged in another way, for a given efficiency, the life of the new lamp is several times as great as the ordinary carbon lamp. It may be mentioned that the *useful* life is taken in each case, *i.e.*, the life during which the candle-power is maintained within 80 per cent of the initial value.

The "Gem" lamps, which are extensively used in the United States, are now being introduced into this country by the British Thomson-Houston Co., Ltd., to whom we are indebted for the use of the above information.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Outdoor Lighting Fixtures.

Messrs. Falk, Stadelmann & Co., Ltd. (83–87, Farringdon Road, London, E.C.), have sent us an advance copy of a catalogue of "EFESCA" ELECTRIC OUTDOOR LIGHTING FIXTURES, in which we note among other features some designs of enamelled iron lanterns for use with "Efesca" and other metal filament lamps. These are made in various sizes, from those suitable for one 100 c.-p. lamp up to a size which will contain a

600 c.-p. lamp or four 50 c.-p. lamps. In addition to these lanterns, which are suitable for shop fronts, doorways, &c., the list includes many larger types of fixtures for street lighting, dock lighting, &c., and accessories for outside lamps such as time switches, &c.

The fitting illustrated above consists of a cast iron water-tight dome, with vitreous white enamelled reflector, arranged to take lamps up to the 200 c.-p. size.

An attractive little book of tables, chiefly in connexion with steam calculations, has been sent to us by **Messrs. Babcock & Wilcox** (Oriel House, Farringdon Street, London, E.C.)

Pharos-Welsbach High Pressure Lighting.

The Welsbach Light Co. (344–354, Gray's Inn Road, London, W.C.) have sent us some notes concerning their Pharos High Pressure Air or Gas System, for which they are the sole agents in the United Kingdom.

The Company is at the present moment making a big display of the Pharos System at the Belfast Gas Exhibition, where a couple of Pharos lamps are fitted at the front of the building, each giving 4,000 c.p. There are also three other lamps of 2,000 c.p. under the archway at the entrance, and their brilliance is said to attract considerable attention. The high pressure plant such as is used in this installation, in which air and not gas is compressed, is suitable for fitting to any ordinary gas main.

High Candle-power Drawn Tungsten Lamps.

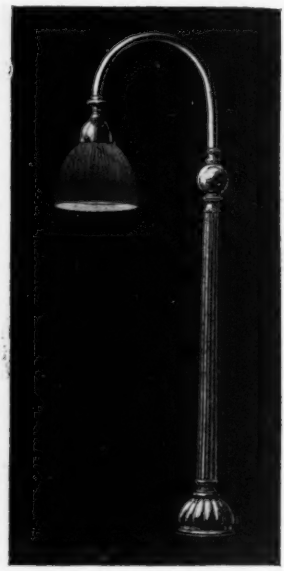
We notice in a list recently issued by **Messrs. Siemens Bros,** that they have now put on the market a 400 watt 360 c.-p. DRAWN TUNGSTEN WIRE LAMP. This is the latest addition to their series of high candle-power "Onewatt" lamps, and has been developed with a view to its use for street and shop lighting.

"Tantalum" Show-Card Competition.

As we go to press **Messrs. Siemens** send us the result of the above competition. Out of nearly 2,000 designs that have been submitted, it has been a difficult task to award the prizes. The two best designs have been bracketed, and the £100 prize has been divided equally between Mr. Frank M. Barton, of West Ealing, and Mr. L. Sutton Wood, of Featherstone Buildings, Holborn. Two other prizes of £5 each were awarded.

A New Fitting for Desk Lighting.

We have received some particulars from **Messrs. Holophane, Ltd.** (12, Carteret Street, Westminster, S.W.), of a new unit for DESK LIGHTING IN BANKS, OFFICES, &c., which they are putting on the market. The new unit consists of an 8 c.-p. lamp fitted with a Holophane reflector, chosen so as to direct the light downwards in the most efficient manner, and this is covered by an opal shade, green on the outside but white within, which screens the lamp from the eye and produces a very soft and pleasing effect. The accompanying illustrations show two different forms of ornamental bracket which have been specially designed to carry the new reflector. In these fittings the height of the lamp above the desk has been arranged so as to give the best distribution of light with the particular reflector used, and we understand that a high degree of uniformity is attained if the lamps are spaced correctly according to the specified distance apart. We note from the curve of illumination, which has been worked out experimentally and is published by the Holophane Company, that an average value of 3½ foot-candles is obtained, and the minimum value (between the lamps) is as much as 3·3 foot-candles.



Safety Handlamps.

We have previously referred to the "Handshield" Plug and other fittings made by the **British Central Electrical Co.** (84, Hatton Garden, London, E.C.). In a list just received from them we notice some designs of SAFETY HAND LAMPS, notably the "Guardian" type, which has been specially designed to pass the Board of Trade requirements, and has been largely adopted by Government Departments, &c.

Arc Lamp Lowering Gear.

The London Electric Firm (George Street, Croydon) have sent us a catalogue which deals exhaustively with all types of LOWERING GEAR for arc and metal filament lamps. This firm, we understand, has specialized in this particular department of lamp design, and their list contains many examples of existing installations both of the swan-neck and span-wire type, in which lowering gear designed by them has been fitted.

The "Diamond" Letter for Illuminated Signs.

We have received from **Messrs. Hill & Harrington, Ltd.** (76a, Great Portland Street, London, W.), an illustrated catalogue describing the special designs of LETTERS FOR ILLUMINATED SIGNS manufactured by them. The faces of the letters are of opal glass, and are set at an angle of 45° to the building on which they are fixed, so that they can be easily read even by a person standing close under the sign. The lamps are protected from the weather by the metal casing of the letter, and the back part of the casing is designed to reflect as much light as possible in a useful direction. The opal glass faces can be easily and quickly cleaned, and are readily replaced if broken. Another feature of this type of letter is that its appearance is bold and effective during the day when no illumination is required.

Automatic Time Switches.

The use of AUTOMATIC TIME SWITCHES is becoming more extensive, and their advantages for certain purposes are now recognized. Two types manufactured by **Messrs. William Geipel & Co.** (Vulcan Works, St. Thomas Street, London, S.E.) are described in a pamphlet we have received from them. In each type an adjustable timing system is provided In the one type this gives a certain number of "restricted hours," during which it is impossible to switch on the current. In the other type the timing system is arranged to give definite times for switching "on" and "off," and these periods may occur once or twice in the twenty-four hours as desired. It is suggested that the first type has a wide field where the reduction of peak load by restricting the supply would be advantageous, and the second type is applicable to street and interior lighting, where limited service only is required.

Messrs. Geipel & Co. also inform us that they have again secured a contract with the London & North Western Railway for the annual supply of HENRION ARC LAMP CARBONS, amounting in all to over a million carbons. They mention that this is the third year that they have secured this important contract.

Eye-comfort

In Interior Illumination

is secured, and eye-strain obviated, by suitably shielding the direct rays of light from the eye, and ensuring that the ceilings and walls are sufficiently brightly lit, without being dazzling.

This effect is most nearly obtained by using

The UNION "EYE-COMFORT" SYSTEM

of Indirect Arc Lighting.

Union Electric Co. Ltd.
PARK ST. SOUTHWARK. LONDON, S.E.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

THERE are a number of interesting articles in *The Illuminating Engineer* of New York. In the editorial portion will be found an account of a series of recommendations issued by the authorities for safeguarding the **Vision of children in Schools** in New York; some of these bear on the lighting. For example, rooms are tabooed in which artificial lighting is exclusively used and it is recommended that frosted lamps surrounded by amber shades be used. Other recommendations are that highly calendered shiny paper and half-tone pictures should be avoided. The same journal contains an article on the use of inverted lighting in shops; also a contribution in which a number of examples of defective illumination of premises given up to tailory work are shown. There is also an illustrated description of some very peculiar forms of table lamps.

Among other American articles we may note that by LUCKIESH (*Elec. World*, N.Y., Aug. 19), who discusses the effect of the "chromatic aberration" of the eye on **Visual Acuity**; it appears that the eye can as a rule only focus rays of one particular colour accurately, and it is suggested that a sharper retinal image would be secured by using monochromatic light.

Among contributions of a more strictly scientific character mention may be made of the paper by O. BUJWID (*J.f.G.*, Sept. 2) on the **Effects of Light on Bacteria.** A feature is the complete series of references, arranged in historical order, to the past literature of the subject. Some of the latest forms of lamps for producing ultra-violet light for disinfecting purposes are shown. The value of this method of sterilizing drinking water is pointed out, especially its application in connexion with localities where the supply has become infected with cholera germs.

O. LUMMER (*G.W.*, Sept. 1 abstr.) describes **A New Method of Optical Pyrometry,** in which the distribution of light in the spectrum of a standard incandescent surface is taken as an index of temperature.

A very complete series of articles on **Radiation and Light Production** is being contributed by R. A. HOUSTON to *The Electrician*. The first of the series is devoted mainly to the measurement of luminous efficiency and its definition, the second deals with the black body and the third with the radiation of flames.

ELECTRIC LIGHTING.

G. CLAUDE (*Comptes Rendus*, May 22), gives some interesting particulars about the new **Vapour Tubes containing Neon.** The difficulty in the past has been the rapid volatilization of the electrodes, but this has been largely overcome by making their surface area larger. The tubes are of comparatively small dimensions, only about 6 metres in length, the light is of a reddish colour, and a life of over 400 hours has already been obtained. In this case it has been found possible to dispense with the special valve which forms a feature of the Moore tube.

A recent paper by H. REMANÉ on the **Applications of Tungsten Lamps** is abstracted in *The Electrician* (Sept. 1). Special attention is paid to street lighting and replies to enquiries received from 185 different towns are tabulated. After making all allowances for renewals, &c., it is calculated that carbon filament lamps can be replaced by tungsten lamps of double the candle-power, and yet a saving in expense made. The lamps are also now proving serviceable in many situations in which they are exposed to considerable vibration, such as collieries.

Several articles, notably that by GIBBS (*Elec. Rev.*, N.Y., Sept. 2) deal with **Illuminated Signs.** The merits of the

"series-parallel" and "all-series" methods of arranging small tungsten lamps are discussed, and the duration of flashing signs commented upon. Many signs flash out their message too quickly for it to be easily taken in by the observer Others tell their story too slowly. Besides attracting attention, flashing methods are serviceable on account of the saving in current secured.

F. KESSELING (*Elek. u. Masch.*, Aug. 27) discusses mathematically the fluctuations in candle-power of glow-lamps run off an alternating supply. His main conclusion seems to be that when a low frequency has to be employed low voltage lamps should preferably be employed. M. DE ROSSI (*L'Electricien*, Sept. 9) deals with the question of small **Transformers for Lighting Circuits**, showing under what circumstances they are economical and giving data for their efficiency and power factor at various loads.

A. E. BREWERTON (*Elec. Rev.*, Aug. 25) points to the enormous waste that often occurs in cinematograph lighting, especially in lamps run on a high voltage; in such cases it is often economical to use a rotary converter to reduce the pressure.

C. H. WILLIAMS (*Elec. World*, Sept. 2) gives an account of some researches on the **Effect of Mercury Vapour Lamps on Vision.** The only effect he appears to have noted was a temporary abnormality of the colour sense. The serial article on improvements in vapour lamps in the *Zeitschrift für Beleuchtungswesen* is concerned largely with methods of **Improving the Colour of Mercury Arcs.** Alloys of certain metals which give off negative electrons freely are specified as being useful for this purpose.

GAS, OIL, ACETYLENE LIGHTING, &c.

We may next notice a series of articles in American journals dealing with special applications of gas lighting. Thus A. M. BERG (*Prog. Age*, Sept. 15) describes the **Lighting of a Bowling Alley** with "Reflex" lamps, the essential point being a form of reflector which concentrates the light downwards, but completely screens the mantle from the eyes of players. Similarly C. F. ANDERSON deals with the **Lighting of Billiard Tables**, and C. R. GRAVES with a **Swimming Bath Installation** (*Prog. Age*, Sept. 1). A. H. JOHNSTON (*Prog. Age*, Aug. 15) briefly outlines the chief methods of **Shop Window Lighting by Gas.** He contends that the essential thing here is *effect*, cost being of relatively small account. The method of arranging screened lamps at the top front of the window so as to throw light back on the goods is recommended, but the ideal system is the "deck-window" in which the sources are placed in a separate compartment, and completely screened from the eye, their light being allowed to stream into the window through frosted glass panels. Another unusual method of lighting is described in an article in *The Illuminating Engineer* (New York) by P. EVES. The system is indirect, the mantles being mounted in metal cup reflectors in clusters of four.

Turning to lamps we may note the account of the new Nico type, which, with ordinary low pressure, is stated to yield as much as 42 c.-p. per cubic foot (*J.G.L.*, Aug. 29; *G.W.*, Sept. 2). This appears to be due mainly to careful design of the mixing chamber and judicious pre-heating of the gas.

Interesting articles by NASS (*J.f.G.*, Sept. 23) and ZDANONICH (*J.G.L.*, Sept. 19) deal with progress in **Artificial Silk Mantles** and microphotographs are given showing how the web of these mantles holds together after 1,000 hours burning much better than those of Ramie. In the latter case the fibres available are not sufficiently continuous, and soon break up, but the artificial silk consists in individual long continuous strands.

Another notable article is that by METZGER (*J.f.G.*, Aug. 26), who gives his experiences of the use of **Distance Gas-lighters.** He shows how the percentage of failures was reduced to within 1 per cent, and that a considerable annual saving was made through the diminution of labour, and the decrease in the numbers of chimneys and mantles broken in lighting up, &c.

The same journal summarizes recent **Improvements in Spirit Incandescent Lighting.** The early difficulties such as deterioration and discolouration of the metal work, smoking of the flame and carbonizing of the wick have been largely got over; they appear to be due partly to impure spirit and partly to the presence of moisture. Reliable lamps are now available, but it is doubtful if they will ever take the place of gas or electricity when these illuminants are available.

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CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*

E. T. Z.—*Elektrotechnische Zeitschrift.*

G. W.—*Gas World.*

Illum. Eng., N.Y.—*Illuminating Engineer of New York.*

J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*

J. G. L.—*Journal of Gaslighting.*

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

Some Publications Received.

Ophthalmia Neonatorum in Ten Massachusetts Cities. By Henry Copley Greene.—The first of a series of monographs published by the American Association for the Conservation of Vision.

Bulletin of the American Association for the Conservation of Vision.—(To both of the above we make fuller reference on page 576.)

Westminster Technical Institute, Prospectus of Evening Classes.—Giving particulars of lecturers and times of classes for the Session beginning in September, 1911.

Among other publications we have also to acknowledge the receipt of the following: *Journal of the Royal Society of Arts, Journal of the Institution of Electrical Engineers, Transactions of the South African Institute of Electrical Engineers, Proceedings of the American Institute of Electrical Engineers, American Chemical Journal, Journal of the Franklin Institute, The Physical Review, Atti della Associazione Elettrotecnica Italiana, Zeitschrift für wissenschaftliche Photographie Photophysik und Photchemie.*

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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

The Electrical Exhibition at Olympia.

THE Electrical Exhibition which has been taking place at Olympia during the last month was naturally an event of interest to all concerned with lighting, and we have therefore taken the occasion to reproduce in the present number two separate articles giving impressions of the exhibition from the illuminating engineering standpoint.

It is generally conceded that the display has been a very representative one, in the sense that electric apparatus from practically all the leading firms has been on exhibition. At the same time we find an impression that there has been little to be seen that was really new. So much interest is taken in lighting nowadays that any important advance in the manufacture of lamps is immediately chronicled in the technical press. The expert is therefore kept well informed on these matters, and we contend that more should be done to educate the general public on these occasions.

In our opinion exhibitions of this kind require to be reformed in several respects before they can command really keen attention from non-technical people. The average visitor, unversed in the technicalities of electricity, is quite at a loss when he finds himself wandering among the series of stalls, arranged in no particular order, and inviting his attention to matters which he does not understand. He also discovers a series of stalls devoted to incandescent lamps, fixtures, &c., most of them repeating practically identical claims and, indeed, appearing in his eyes almost the same as regards general contents.

As these stalls are arranged he is afforded no proper opportunity of judging what the various lamps, shades, &c., can do. Insufficient

attempts are made to demonstrate the lighting capabilities of these articles. Indeed, very often even he, the non-technical man, receives the impression that their use is not understood by the exhibitor (*e.g.*, he sees bare lamps placed in the direct range of view, reflectors tilted so as to throw the light straight at him instead of illuminating any particular object, &c.), and in many cases the effect of any particular fixture is entirely spoilt by the glare of neighbouring powerful lamps. From his standpoint the exhibits are unsatisfactory in three respects: (1) they are not arranged in sections, (2) there is much needless repetition, and (3) the value and use of the lamps and fixtures is not properly demonstrated.

The suggestion has already been made, and in our opinion it is one to be considered, that in future such exhibitions should be arranged sectionally, one part of the room being given to lamps and illuminating appliances, another to measuring instruments, a third to machinery, &c., so as to avoid needless repetition in the devices shown. These sections might be clearly indicated to visitors by bold illuminated signs in different colours. This method demands systematic co-operation and a concerted scheme with a view to making the exhibition as convenient and impressive as possible *as a whole.*

There should also be a special effort made to demonstrate the *uses* of these lamps and fixtures for illuminating various kinds of interiors, dining-rooms, shop windows, picture lighting, &c. — some attempt to produce a novel and striking effect which would really deserve to command public attention because it was something new and useful. These demonstrations should be supplemented by properly equipped and organized lectures and demonstrations by specialists in the various sections.

Lastly, there should be a more deliberate attempt to scheme out the lighting of the exhibition as a whole, both with a view to the convenience of the public and the production of artistic and decorative effects. Seeing that such wonderful possibilities in spectacular lighting by electricity are now possible, it seems incredible that so very little originality and artistic skill should have been shown in this direction. There is no object in reproducing methods of illumination which people can see in any moderately well lighted street or office. Moreover, local exhibitions are constantly being organized in different parts of London where all the latest novelties can be seen, on a smaller scale than at Olympia certainly, but frequently in a more convenient manner for public inspection. Naturally, therefore, a person who can see things almost at his door and for nothing will not undertake a railway journey and pay the entrance fee, unless it becomes known that something exceptionally interesting and instructive is to be seen by doing so. But let some novel and perfect exhibitions of the use of these illuminants be devised, and both press and public will be only too anxious to support them.

Reduction in Price of Metallic Filament Lamps.

Much interest has been excited by an announcement, on the part of the leading makers of metallic filament electrical incandescent lamps, of a further substantial reduction in price. Almost simultaneously we heard of the new 16 candle-power 20 watt metallic filament lamps for high voltages brought out by a well known company.

From the purely scientific standpoint it is doubtless gratifying to see these signs of progress, and to observe how the drawbacks under which the metallic filament lamps originally laboured have been steadily overcome. Yet we cannot help thinking that there is a broader aspect of the ques-

tion that suppliers of electric lamps would do well to bear in mind. It was inevitable that the introduction of highly efficient lamps should have threatened a loss in revenue to electric supply companies. If they have so far been able to avoid serious financial difficulties, it has been mainly because lamps of small consumption were not originally available, so that although the consumer secured more efficient lamps he was obliged to use more light; consequently, the actual reduction in electrical power consumed was not so great as it would have been had 8 or 16 candle-power lamps been available from the start.

But with the advent of the 12 and 16 c.-p. 100 volt lamps the inconveniences of supply authorities became more apparent, and already a number of companies have been obliged to raise their rates. The net result, therefore, of low candle-power lamps in many cases is that less electricity and light are used, but are paid for at a higher rate. If 20 watt high voltage lamps and cheaper lamps *in addition* are to be offered to the public, and little additional load can be secured, the position of the supply companies will become more difficult still, consequently a further rise in rates will in all probability be made. We have no desire to hinder progress, but wish to emphasize the fact that new steps of this kind should be regulated by mutual understanding.

We cannot help thinking that this lack of effective co-operation between the supply companies and the lamp makers on this matter should be remedied.

We may recall that when the incandescent mantle threatened a loss in revenue to the gas companies, it was largely the fact that the new units gave much more light at a somewhat smaller gas consumption that enabled them to tide over the inconvenient transition period. To our mind it would be much better if lamp makers were to devote their efforts to securing really excellent lamps of moderate consumption and to defer hastening the introduction of units, which are really too small for effective use in the majority of practical cases.

The result of this continual insistence upon increased economy is that the public, instead of being encouraged to be more liberal in the use of light, are rendered more grudging in this respect. Yet it is an admitted fact among experts that the glare from the bare filament demands screening methods which entail a certain loss of light. With the more powerful and efficient lamps now available the consumer could, if need be, afford some loss in light, although, as a matter of fact, the use of the latest scientific glassware enables him to suffer very little in this respect. He could secure a higher standard and a *better arranged system of illumination*, and yet save something on his bill.

We firmly believe that improved illumination and reasonable bills will be the inducement which will appeal to consumers more and more as time goes on. Those companies which grasp the opportunity now of adopting for their motto the scientific *use* of light will reap their reward in the near future.

The Turin International Congress of Applied Electricity.

In our last number an account was given of the proceedings at the last meeting of the International Electrotechnical Commission, and on page 616 in this issue will be found a summary of the International Congress on Applied Electricity which followed.

The event of greatest interest to us was, of course, the resolution to form an International Commission to deal with all questions relating to illuminating engineering, but on this, too, we have already commented. We need only point out the excellent precedent set by the action of this Electrical Congress in appointing a Commission to deal, not exclusively with electric lighting, but with *all illuminants*; and also to include within its scope the

measurement of illumination and practical lighting problems. The co-operation of the Illuminating Engineering Society, whose unique ability to deal with this matter in an impartial and international manner has received such gratifying recognition from the Congress, will doubtless be of great service in putting this great step into execution.

We should next like to take the opportunity of drawing attention to the exceptionally pleasant relations which marked the Congress, and the valuable series of papers presented; many of these communications deserve fuller consideration than was possible in the necessarily short time devoted to their discussion, and this series of papers (over eighty in number) will doubtless form a valuable collection of information for future reference.

Two incidents which struck us as particularly appropriate to the occasion were the demonstrations of homage to the memory of Galileo Ferraris and to the genius of Prof. Antonio Pacinotti, still happily with us. There were also a series of visits to installations in the neighbourhood, all of which illustrated the wonderful progress that has been made in applied electrical science in Italy during the last few years.

One other matter we should like to mention. It will be recalled that the Congress unanimously resolved to entrust the care of future congresses to International Electrotechnical Commission, working in co-operation with the local committees and institutions interested. The unanimous approval with which this decision has been greeted testifies to the widespread recognition and confidence which the Commission now receives, and we feel sure that the step will be a most beneficial one for the electrical industry.

The Courses of Lectures in Illuminating Engineering.

Some time back* we expressed the hope that a series of lectures on illuminating engineering would shortly be established at various educational centres in London. As readers will have seen from the notices appearing in our recent numbers this desire has been realised. Special courses of this kind have now been arranged at three institutions in different parts of London, namely the Regent Street Polytechnic, the Battersea Polytechnic, and the Northampton Institute.

It may be added that these lectures have been organised with the consent of the Educational Department of the London County Council, which has shown a keen appreciation of the need for better facilities for instruction in illuminating engineering. We feel confident that the enterprise shown by the principals and governing bodies of these institutions in this direction will be amply justified.

The opening lectures at Battersea have already been delivered on Oct. 17 and 24 respectively, and the course at Regent Street Polytechnic is commencing on Oct. 31. We hope that the lectures will be of value to many members of the Illuminating Engineering Society as well as those outside, for the opportunity provided of hearing an impartial discussion of different illuminants and their applications is certainly an exceptional one.

We should also like to commend these lectures to the notice of other education institutions which will doubtless wish to arrange courses of this kind in the future; and to those societies and associations, which are responsible for framing educational programmes for the members of their respective professions.

The present series of lectures may be regarded as a preliminary to more extended and complete courses of instruction, and we hope that, in the course of time, education on this subject will become an integral part of programmes of studies for architects and engineers, so that the expert, having the qualifications of the ideal illuminating engineer, will eventually be evolved. LEON GASTER.

* *Illum. Eng.*, Aug., 1911, p. 441.

Review of Contents of this Issue.

On page 613 will be found the conclusion of the article by Prof. A. Blondel and Mr. J. Rey on **The Perception of Lights of Short Duration at their Range Limit.** They apply the formula previously deduced to two typical cases in flashing lights. First, assuming that the time of the flash is determined, what is the intensity of the light source which will give a maximum output; and, secondly, with a given source of light, and a given interval between the flashes, what is the best period of flash to employ? The authors also describe some experiments they have carried out on the time and number of flashes required in taking bearings. They find that, whatever the period, the taking of bearings always demands about the same number of flashes. The article concludes with a brief recapitulation and summary of conclusions.

A brief account of the **International Congress of Applied Electricity,** held recently in Turin, appears on page 616. Reference is first made to the large number of delegates present and the complete international representation; then follows a short description of the opening ceremony and some notes on the special facilities granted to members for viewing the exhibition and places of technical interest in the neighbourhood. Two graceful incidents were the presentation to Prof. Antonio Pacinotti and the placing of wreaths on the monument of Galileo Ferraris. A mention is made of the principal papers in the various sections, and, finally, the chief resolutions are summarized. One of these, emanating from the Section on Illumination and Heating, and advocating an International Commission on Illumination, was of especial interest.

A proposal of Prof. R. A. Houston with regard to an **Absolute Standard of Light** is dealt with on page 618. The proposed method of measuring intensity of light involves the use of a thermopile, which would, under ordinary conditions, give a measure of the total radiation from the source. Prof. Houston therefore proposes to employ a light filter between the thermopile and the source of light, which has the property of stopping all the infra-red and ultra-violet radiation, and of cutting down the energy of the visible spectrum in inverse ratio to its light-producing effect.

On page 620 is a short account of the first two lectures of the **Course on Illuminating Engineering** now being given at Battersea Polytechnic. These lectures were delivered by Prof. J. T. Morris, on the subject of 'Electric Lighting,' the first dealing mainly with incandescent glowlamps, and the second being concerned with arc lamps and vapour lamps.

Following this is a summary of the papers read at the Fifth Annual Convention of the **Illuminating Engineering Society (U.S.A.)** (pp. 621–628). The **presidential address** of Prof. Kennelly was mainly concerned with the measurement of light and the importance of this to the industry of illumination as a whole.

The sub-committee on **Photometric Units** reported that they had been in communication with a number of the principal authorities in foreign countries with a view to getting international agreement on the subject of units, and several valuable suggestions had been received in reply. Certain recommendations were put forward by the committee regarding terms and symbols. Two papers also dealing with the subject of photometry were those of Dr. Louis Bell, on **Photometry at Low Intensities,** and of Messrs. G. H. Stickney and S. L. E. Rose on the **Testing of Large Light Sources.**

MR. E. L. ELLIOTT contributed a paper summarizing the legislation of various countries on the subject of illumination, while an interesting paper by DR. H. E. IVES and M. LUCKIESH deals with the **Distribution of Brightness in Nature.** A large amount of evidence on the special characteristics of daylight has been obtained by means of photography, and the authors show how these support the fundamental rules of good lighting. MR. J. E. RANDALL points out the chief improvements in **Electric Incandescent Lamps** during the last few years, and MR. F. H. GILPIN, in a paper on **small gaslighting units,** draws attention to the value of the small candle-power mantles now available, which yield an exceptionally high efficiency. Quite a number of papers deal with the subject of **Illuminating Glassware,** stress being laid on the importance of decorative and artistic design and the possibilities of opal reflectors. MR. J. R. CRAVATH, in an interesting paper on **The Effect of Surroundings on Acuteness of Vision,** describes some tests on reading under different conditions of illumination which he has carried out with several observers. A brief reference to other general papers concludes this section.

On page 628 an Engineering Correspondent contributes some notes **Mercury Vapour Lamps giving White Light.** He refers to the deficiency in red rays of the Cooper Hewitt lamp, and the consequent distortion of colour, and then describes some of the early attempts of inventors to overcome this objection. The first idea was to add some gas inside the tube to improve the spectrum; then metallic ingredients were added; but none of these methods proved satisfactory. Attention was then turned to the possibility of adding the red rays from *outside* the tube, and ultimately this resulted in the production of the rhodamine fluorescent reflector. This has the effect of transforming certain of the blue rays, and even some of the ultra-violet rays, into the red rays which are lacking in the spectrum of the ordinary tube.

The Lighting of the Westminster Public Library is briefly described on page 632, and illustrations are given showing the scheme of illumination adopted in the ratepayers' reading-room and the newspaper room.

Following this is a note on the **lighting of an Artistic Interior,** in which silk shades and tungsten lamps are utilized with considerable effect. A photograph is reproduced which shows the soft and subdued light obtained by this means.

Artificial Illumination and Scenic Effects in Switzerland is the subject of a note on page 636, in which reference is made to the lighting of some of the natural gorges, and the effect of searchlights which send out their beams from some of the mountain hotels.

An abstract of a paper by H. METZGER on **The Advantages of Automatic Distance Gas Lighting** will be found on page 637. He traces the development of distance lighting by means of a rise in pressure, and shows how the difficulties incidental to this system have gradually been overcome. In Bromberg a preliminary trial of the apparatus was arranged before the automatic system was generally installed. Two firms supplied apparatus under severe conditions of guarantee, and the advantages of the system were fully established. A diagram is given showing the number of failures of the automatic apparatus of both types during eight successive months. On the average these do not exceed 1 per cent in either case, which is the order of accuracy specified.

On page 641 an Engineering Correspondent contributes an illustrated description of the **Electrical Exhibition at Olympia,** with special reference to the exhibits of interest to illuminating engineers, and this is followed by Some Impressions of Illumination at the Exhibition. This second article deals somewhat more critically with the lighting of the exhibition from the point of view of the casual visitor. At the conclusion of these articles some suggestions are made as to how the conditions of illumination at future exhibitions might be improved.

Subsequently will be found some Short Notes on Illuminating Engineering, the Trade Notes, and the usual Review of the Technical Press.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

On the Perception of Lights of Short Duration at their Range Limit.

By Prof. A. Blondel and J. Rey.

(*Concluded from page 562.*)

After what has been stated, it is proper to draw a distinction, first of all, between two cases, according as the optical apparatus or the source be supposed to be given as datum.

First Problem.—*Given an existing optical apparatus, allowing of the total flux of light being subdivided into rapid, concentrated flashes every T second, what is the source of light which will permit the maximum output to be derived from this apparatus?*

It is very evident that it is the most powerful source of light without, correctly speaking, giving any limit to its power.

The only limit is the excessive expenditure necessitated by the use of very powerful sources of light, and by the reduction of the specific output itself; for, in the case of certain sources of light, such as some incandescent mantles, the increase of luminous area is accompanied by a diminution in intrinsic brilliancy.

Any increase in the diameter of a source of light obtained without a corresponding increase of the flux (as might be obtained, for instance, by interposing diffusing glasses) would only increase the period of excitation at the expense of intensity, and would be prejudicial to the output of the optical apparatus.

Second Problem.—*Given a source of light and the interval T between the flashes into which its total flux must be concentrated, what is the most advantageous flash-time that can be obtained by the optical apparatus in order to acquire the maximum output of the said source of light?*

This is a problem which the constructor of the optical apparatus must set himself in order to know if it is more advantageous to increase or to reduce the time of the flashes. The quantity of illumination ($L=Et$ lux-seconds) disposable for the flash is assumed constant, and is proportional to the total flux distributed on the horizon divided by the number of flashes. Hence the efficiency of the apparatus will be so much the weaker as the period of the flash is prolonged.

The remarks on this point on page 561 (formula 3) show that the advantage gained by increasing the intrinsic brilliancy of a source, for instance, in the ratio m, is much greater than that secured by increasing the duration of the flash in the same proportion; for the multiplication of the time by m increases the apparent intensity of an equivalent fixed light in the ratio:—

$$\frac{m\,t}{0{\cdot}21+m\,t} : \frac{t}{0{\cdot}21+t} = \frac{m\,(0{\cdot}21+t)}{0{\cdot}21+m\,t}$$

an expression which tends towards unity as t becomes greater; whereas if the intrinsic brilliancy of the source is multiplied by m, the intensity of the equivalent fixed light is increased in the same proportion—*e.g.*, if $m=2$, the apparent intensity of the flash light will be doubled. Conversely, if the diameter, and consequently also the duration of a light, is doubled, the ap-

parent intensity will be increased only in the proportion of $\frac{2+1}{21+2} = \frac{4}{3}$, approximately, so that the increase will be only 33 per cent instead of 100 per cent.

The flux should therefore be concentrated in the shortest time possible without there being any inferior limit for this period of concentration. The formula (6) shows that there are two ways of effecting this concentration. On the one hand, we may increase the focal length R of the apparatus, which results in the concentration of the flash into a smaller angle (inversely proportional to the focal length); on the other hand, we may reduce the number n of beams of the optical apparatus and increase their rotatory speed or the number of revolutions per second N, in inverse proportion, so as to re-establish the prescribed number of flashes per second $t=N$.

Another important advantage which was placed in evidence by one of us in 1893*, is that the shorter the signals, the more rapidly does their visibility increase when the observer, starting from the range limit, draws near the point of emission.

There is also another possible advantage in reducing the period, which has been pointed out to us by Mr. George Guy. Such a reduction serves to prevent the retina from moving while the flash is passing, so that the image of the luminous point accumulates its excitation on one and the same point of the retina, and the maximum subjective luminous effect is thus secured.

Case in which the Flash has not a Constant Photometric Intensity during its Period.—In order to simplify matters, all the preceding deductions have been made on the assumption of a flash preserving a constant intensity during the whole of its period of application on the eye; but, in practice, this condition is never obtained.

We have shown that the efficient excitation at any moment is proportional to the difference $E - E_o$ between the real illumination E and the limiting threshold illumination E_o (Fig. 6). If we denote by t_1 and t_2 the moments when E becomes equal to E_o at the beginning and at the end of the flash respectively, the integral of excitation can be obtained by the simple quadrature with the planimeter of the curve shown in Fig. 6. It must be understood that we accept this integration only for flashes of short duration, such as are employed in actual practice, that is to say, lasting at most a second; but we have not sufficient experimental data permitting us to know within what limits the excitation can be integrated for longer periods. If this integration gives as a result an area greater than the value aE_o, which, according to the equation (2), corresponds to the intensity actually perceived, it must be concluded that the theoretical limit has not yet been

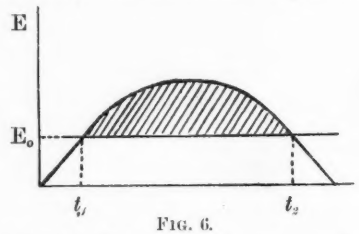

FIG. 6.

attained. This range limit is reached when—

$$(7)\quad \int_{t_1}^{t_2} (E - E_o)\, dt = aE_o,\ (a = 0{\cdot}21 \text{ about.})$$

The integral can be determined if we know the form of the polar curve of the lateral variation in intensity measured in the beam.

By this method we can also obtain the horizontal intensity I'_h of a fixed light giving the same range limit as the brief light defined by the polar curve:—

$$I'_h = \frac{\int_{t_1}^{t_2} I_h dt}{a + (t_2 - t_1)}$$

Remarks on taking the Orientation Bearings of Lights of Short Duration.—In all that precedes we have given

* Loc. cit.

our attention only to the impression produced on the retina by brief lights; it may be asked, on the other hand, whether the period of the flashes has any influence on facility in taking the bearings of the direction of the luminous point. Naturally, as in all that has been previously stated, it is only a question of comparing short flashes of a duration of less than a second and seen in the vicinity of their range limit.

For this purpose we have employed for scrutinizing the luminous point an alidade moving round a vertical axis, and supplied with two vertical wires feebly lighted to render them just visible: the values chosen for the period and for all the observers have been 0·01, 0·03, 0·1, 0·3, and 1 second; to perfect the pointing of the alidade on to the luminous point, the number of flashes necessary for each observer was counted. For each observation taken the intensity of the luminous point was regulated in such a manner as to give exactly the range limit, according to the new law established.

The following averages, each taken from the results of five observers, have thus been found :—

Period of the flashes.	Average of the number of flashes for levelling.
1/100	4·7
3/100	4·65
1/10	4·6
3/10	4·94
1 second	5

It is therefore seen that, by passing from 1-100th of a second to 1 second, that is to say, for flashes varying in the ratio of 1 to 100, the differences were very slight, since they do not exceed 8 per cent, differences insignificant in practice, and which, moreover, present the character of accidental errors.

It is seen in fact that the taking of the bearings always demands about the same number of flashes, whatever the period, and that this period has no marked influence.

It is otherwise for the interval between the flashes, for experience has shown that it is not practical to increase it beyond 5 seconds, and that the shorter the interval, the easier and the quicker the observation.

RECAPITULATION AND CONCLUSIONS.

To sum up, we have shown how, by theoretical considerations, one can ascertain the form of the most probable law for establishing the relation between the intensity and the period of a short light producing the minimum of perceptible sensation.

We have afterwards described new methods and apparatus which allow of the experimental study of all the phenomena of perception of lights of short duration, point sources of negligible dimensions, by comparing two brief lights of a different period, one of which serves as a standard.

By comparing a large number of measurements made by numerous experimenters on the minimum perceptible illumination, and by eliminating, as far as possible, by the calculation of geometrical averages, the divergences which inevitably exist in measurements of this kind, we have obtained a satisfactory verification of the law sought for between the illumination and their periods of application on the pupil. In the case when uniform lights are used, we have expressed this law in the simple form :—

$$(E - E_0)\ t = a\ E_0,$$

E_0 being the minimum perceptible illumination and a being a constant of time of about 0·21 second. We have next shown that by simple integration one can deduce the law of non-uniform flashes and the intensity of the equivalent constant light from the point of view of range, namely :—

$$I_h = \frac{\int_{t_1}^{t_2} I_h dt}{a + (t_2 - t_1)}$$

Finally, we have shown, by applying the preceding law, that the most efficient utilization of a source of light must demand short flashes without its being necessary to take any notice of the lower limit to the period of the flashes, except in case of telegraphic signals. It, moreover, suffices that the period of the flash $t_2 - t_1$ should become negligible in presence of the constant a, in order that a maximum efficiency may be obtained.

The International Congress of Applied Electricity.

(*Held in Turin, Sept. 10th–17th,* 1911.)

THE International Congress of Applied Electricity which met in Turin at the end of September accomplished a good deal of useful work and paved the way for greater usefulness in the future. There were present official delegates from 19 different countries, and the Institution of Electrical Engineers in this country was represented by Mr. Alexander Siemens, Prof. Silvanus P. Thompson, Col. R. E. Crompton, Mr. R. Kaye Gray, Major W. A. J. O'Meara, Prof. T. Mather, Mr. W. Duddell, and P. F. Rowell (Sec.).

Prof. S. E. Boselli opened the proceedings with an address of welcome to the visitors, referring to the fact that the Royal Polytechnic Institute in which they were assembled, had once been the seat of the original school of Galileo Ferraris. Prof. L. Lombardi referred to the warm support given by the Italian Government and by H.R.H. the Duke of Abruzzi to the Congress; the special thanks of the members was also due to Prof. Grassi, Signors Lignana, Nizza and Luino and to the organizing secretaries Signor Curti and Signor Semenza for the valuable work they had done in arranging the details of the meeting. His Excellency Signor Calissano, Minister of Posts and Telegraphs, then formally opened the Congress, expressing a welcome on behalf of the Italian Government and subsequently presented an illustrated volume containing a valuable and comprehensive account of recent developments in electrical engineering in Italy.

In addition to the sectional meetings of the Congress and the plenary meetings at which several formal resolutions were passed, there were several interesting excursions and other events. Opportunities were afforded for inspecting the 3,000 volt three phase system on the Genoa-Milan and Genoa-Turin electric railways, and the extra high tension transmission at 30,000 volts from Novalesa to Turin; members also had the privilege of being conducted through the electrical section of the Exhibition by Prof. Arno.

On September 13th Prof. Antonio Pacinotti was presented by Prof. Lombardi, on behalf of the Associazione Elettrotecnica Italiana, with an illuminated album containing the names of members of the Congress and Prof. S. P. Thompson added a few graceful words; to many of those present it was doubtless an unexpected pleasure to meet one whose name is so inseparably connected with so much valuable pioneering work on dynamo-electric machinery. On September 15th, honour was done to the memory of Galileo Ferraris, and wreaths were placed on his monument by representatives of electrical engineers in France and the United States; the British representatives also contributed a bouquet of flowers. M. Hartman of Frankfort recalled the famous transmission experiments of Ferraris in that city. We can only refer briefly to the large number of papers which were presented at the sectional meetings of the Congress (over 80 in all).

In the first section, dealing with Electrical Machinery and Transformers, a paper was contributed by Prof. Silvanus P. Thompson on Rotary Converters and Motor Generators in which he dealt with many of the special applications of machines of this class. The majority of papers in this section were concerned with alternating current plant. Other papers of special interest in the section were those by Dr. H. Behn Eschenberg on the design of electric machinery by Dr. E. H. Stockar on the use of aluminium for transmission lines.

A large number of papers were presented in the section devoted to electrical measuring instruments. Some very practical information on the sub-

ject of meters was given by Dr. C. H. Sharp, while among the papers dealing with the more scientific aspects of engineering should be mentioned the admirable contribution by Prof. A. E. Kennelly on the rotating electric field and Dr. C. P. Steinmetz's communication on transient electric phenomena.

In the section devoted to illumination and electric heating, several papers of special interest to our readers were presented, Dr. Monasch in a communication on metallic filament glowlamps, gave some comparative life tests on direct and alternating current, which suggested that somewhat less favourable results were obtained in the latter case. Signor Pasqualini dealt with parabolic mirrors and described a new method of testing their qualities. The paper by Mr. Leon Gaster on 'The Scientific Outlook in International Illumination has already been reproduced.* Subsequently an important resolution was passed which, in a slightly amended form, will be found among those confirmed at the subsequent plenary meeting. Mr. C. Rossander, the president of this section, dealt in a summary manner with electric heating. A contribution by M. Hess on the installation of arclamps in series on 6,300 volts, is of special interest.

In the section on telegraphy and telephony, Major W. A. J. O'Meara read a comprehensive paper on 'Multiple Telegraphy' and a communication from Dr. V. Poulsen on wireless telephony aroused considerable interest.

Section 7 dealt mainly with accumulators and electro-chemical apparatus; the present position was ably summarized by Prof. Bockhann, and some interesting data were given by Dr. Sharp and others on the Edison cell. The contribution by Prof. Dr. R. Arno to the eighth section, which was concerned with Tariffs, and legislation on electrical matters, contained some distinctly novel suggestions in connexion with charges for alternating current supply, and other contributions contained a summary of the existing legislation on electrical matters in various countries.

* *Illum. Eng.*, Lond., vol. iv., Oct. 1911, p. 569.

Resolutions.

In section 3, a resolution, moved by Prof. Grassi, was unanimously accepted, congratulating the American Institute of Electrical Engineers on its system of placing in parenthesis after values expressed in British measures, the equivalent value in the Metric system, and expressing the hope that the technical societies in countries where the Metric system is not officially employed, would follow this example.

The following important resolution emanating from Section 4 was also adopted:—

"That this Congress deems it desirable that an International Commission should be nominated in order to study all systems of lighting and technical problems connected therewith; and, having been informed that the Illuminating Engineering Society of London has the intention of forming such a Commission, and of putting itself in touch with the other existing national and international photometric committees, approves their taking the initiative in this respect."

This resolution was proposed by Mr. Leon Gaster at the meeting of Section 4, and after modification with the approval of the President of this section, and the proposer, was subsequently unanimously passed at the General Meeting.

In Section 5, Mr. C. A. Mailloux moved a resolution regarding the measurement of the acceleration of trains, and it was agreed that this acceleration should be expressed in kilometres per hour per second.

Two resolutions were adopted in Section 6. The first of these related to legislation with regard to extensive distributing systems, while the second was concerned with taxation in the production and sale of electrical energy.

Lastly, an important resolution regarding the organization of future congresses (to which we briefly referred in our last issue) was passed, namely, that

"This Congress resolves to request the International Electrotechnical Commission to undertake the duty of organ-

izing future Electrotechnical Congresses, determining the objects of such congresses, the date and the place of meeting, and that the details of administration of such congresses should be confided to the National Electrotechnical Committee in the country in which the congress is to be held, receiving assistance when necessary from the technical societies in that country."

The holding of these two meetings together in future should ensure a satisfactory international representation, judging from the large number of delegates present in Turin this year, and it is felt that this co-operation will be beneficial in many ways.

In conclusion it should be added that much of the success of the Congress was due to the untiring efforts of Prof. L. Lombardi, the President, Prof. G. Grassi, and Signor G. Semenza, the General Secretary.

A Proposed Absolute Standard of Light.

It will be recalled that at a recent meeting of the International Photometric Commission, Prof. H. Strache made a suggestion regarding a possible absolute standard of light.* He proposed to measure the radiation from an incandescent body by means of a thermopile, the radiation at each point in the spectrum of the light source being cut down by means of diaphragms so as to be identical with the curve, determined by Lummer and others, which shows the relative sensitiveness of the eye to light of different wave lengths. In this way the thermopile would give a galvanometer deflection proportional to visible radiation only. This method, therefore, necessitates the breaking up and reassembling of the spectrum.

Prof. R. A. Houston, in a communication to the Royal Society in May last, described a method that he has employed for measuring the intensity of a light source, which also involves the use of a thermopile, but differs from the proposal referred to above in the means of cutting down the non-visible radiation. The author in his experiments has placed a light filter between the thermopile and the source of light, which has the property of stopping all the infra-red and ultra-violet radiation and of cutting down the energy of the visible spectrum in inverse ratio to its light-producing effect. Thus the deflections are proportional to the light received.

In order to obtain a filter which satisfactorily fulfils the above conditions, a series of researches were undertaken on the absorption of light by aqueous solutions of inorganic salts in the ultra-violet, visible spectrum and infra-red. As a result of these experiments, the most suitable filter has been found to be a 3 cm. thickness of copper sulphate in water, of concentration 0·200 gramme-molecule per litre, followed by a 1 cm. thickness of potassium bichromate of concentration 0·0025 gramme-molecule per litre. The curve of absorption for this combination, as given by the author, agrees with the curve calculated from figures for the relative visibility of light of different wave-lengths, determined by Prof. A. König, and given in a paper by P. G. Nutting.* In the shorter wave-lengths, the agreement is closest with a curve calculated for an illumination of 2·30 metre-candles, while for the longer wave-lengths a curve calculated for an illumination of 9·22 metre-candles gives very close agreement. Hence it may be assumed that when the illumination of the field is about 6 metre candles, the filter in question will cut down the radiation correctly according to its visibility to normal colour vision.

* *Illum. Eng.*, Lond., vol. iv., Sept. 1911, p. 513.

* The Luminous Equivalent of Radiation, *Bull. Bureau of Standards*, 1908, vol. v. p. 279

If some other illumination of the field is taken as a standard, it is possible to adjust the filter by diminishing the concentration of the copper sulphate and increasing the concentration of the potassium bichromate, or *vice versa*.

The amount of light lost by reflection at the glass surfaces or by absorption in the glass of the cells can, it is suggested, be determined once for all by filling the cells with water and using a spectrophotometer to determine the fraction of the incident light transmitted. The galvanometer deflections can then be corrected accordingly.

The results of actual measurements made in this way and compared with photometer readings are given by the author and they indicate a very close approximation to the linear relation, *i.e.*, the galvanometer deflections are almost exactly proportional to the candle-power. This method might therefore be conveniently applied to the measurement of candle-power, and particularly of mean spherical candle-power by the use of a number of thermopiles connected in series with the galvanometer, but it cannot be considered suitable for commercial application. On the other hand it enables the unit of light to be readily defined, and the author suggests the following definition :—

"The unit of light intensity is that source the total intensity of radiation from which at an optical distance of 1 metre after passing through an ideal filter would be x ergs/cm. sec., the ideal filter to be one possessing the light absorbing properties of a 3 cm. thick aqueous solution of $CuSO_4$, $5H_2O$ of strength 0·200 gramme-molecules per litre and a 1 cm. thick aqueous solution of $K_2Cr_2O_7$ of strength 0·0025 gramme-molecules per litre, but neither to reflect nor to absorb any light in any other way."

A rough determination by the author gives x as 0·8 in the units specified.

The Effect of Alternating Current on the Life of Metallic Filament Lamps.

An elaborate series of tests on various types of metallic filament glow-lamps have recently been undertaken by Prof. A. Turpain and H. Nicoleau, and the results are recorded in *La Revue Electrique*. A feature of considerable interest which is strikingly brought out by the curves and tables in which the results are displayed, is the shortness of life exhibited by the lamps which were run on alternating current. Several of the lamps did not last 1,000 hours, and only one (Osram 50 c.-p.) exceeded 2,000 hours, whereas on continuous current the average life was over 2,500 hours. In all the types tested, this reduction of life on alternating current was found, and the authors naturally ask themselves the question—to what can this difference be attributed? They suggest as a possible explanation the fact that the alternating current system of Poitiers, the town in which the experiments were carried out, is subject to considerable fluctuations in voltage, due in part to the large number of motors in circuit. It is significant that, since the earlier experiments by the same authors in which this particular effect is not so noticeable, the number of motors on the system has largely increased. The vibration of the filament due to the alternating current is also considered by the authors to have its effect in shortening the life of the metal filament lamp.

Lectures on Illumination at Battersea Polytechnic.

THE first of a special series of twelve lectures on 'Illumination,' arranged to take place at Battersea Polytechnic, was delivered by Prof. J. T. Morris on Tuesday, October 17th. The lecturer dealt first with the manufacture of incandescent glow lamps, and brought out several interesting points with regard to efficiency and life in comparing carbon and metallic filaments. A slide was exhibited showing the actual thicknesses of metallic filaments in common use, and the great strength of the new drawn-wire Mazda filament was demonstrated by using it to lift a weight of over 2 lb. A large selection of the latest types of lamps was on view at the close of the lecture, including the new 200-volt 16 c.-p. lamp introduced by the G.E.C., and the extra high candle-power metal filament lamps, which, the lecturer pointed out, might become close rivals to the arc lamp on account of their low maintenance cost. In conclusion, Prof. Morris expressed his thanks to the General Electric Co., the British Thomson-Houston Co., the Edison & Swan Co., and Messrs. Siemens Bros., Ltd., for arranging an excellent display.

At his second lecture on October 24th, Professor Morris took as his subject lighting by arc lamps and vapour lamps. The difference between the ordinary and cored chemical carbon was demonstrated, and the effect on the arc of using a hollow carbon filled with chalk was shown. Incidentally the lecturer referred to the new automatic feed projector arc of the Union Electric Co., using one vertical and one horizontal carbon, an example of which was in use in the lantern throughout the evening. In dealing with flame arc lamps, special attention was drawn to the difficulty of enclosing them owing to the rapid deposit of products of combustion. A full size sectional model, kindly lent by the Jandus Arc Lamp Co., gave a clear idea of their method of overcoming this difficulty. After a passing reference to the Moore tube light the lecturer exhibited the Cooper Hewitt mercury vapour lamp, explaining the action of the new rhodamine reflector used in conjunction with this lamp for producing a light more nearly approaching white. The advantages of using quartz instead of glass for the tube in the mercury vapour lamp were pointed out, an example of this type, the Silica lamp lent by the Westinghouse Cooper Hewitt Co., being exhibited. The lecturer again expressed his thanks to the firms who had provided lamps for purposes of demonstration.

In the next lecture, on October 31st, Mr. J. G. Clark, dealt with 'Gas Lighting.' On the same date a similar course of lectures commenced at the Regent Street Polytechnic.

Popular Lectures on Illumination.

WE are glad to notice, in addition to the complete courses of lectures on illuminating engineering which have been arranged at the Regent Street and Battersea Polytechnics, another instance of the desire for further knowledge of this important branch of engineering. Mr. F. H. Taylor, a member of the Illuminating Engineering Society, has recently delivered some popular lectures on the recent developments of electric lighting at the Willesden Polytechnic. In the course of his second lecture, Mr. Taylor dwelt on the bad effects of glare, and pointed out the possibilities of eliminating these effects to a large extent by the use of modern shades and reflectors. The ease with which illumination can now be measured by means of such instruments as the lumeter was also demonstrated. At the conclusion of the lecture a suggestion was made that the lecturer should be invited to give similar demonstrations in various parts of the parish, so that the advantages of modern methods of lighting should be properly placed before the public.

The Fifth Annual Convention of the Illuminating Engineering Society in the United States.

(Held in Chicago, Sept. 25th, 26th, 27th, and 28th, 1911.)

We have now received particulars of the interesting series of papers read at the Fifth Annual Convention of the Illuminating Engineering Society in the United States. We hope to deal with some of these more fully in subsequent numbers and meantime take the opportunity of giving a summary of their contents.

Physical and Physiological Research in Illuminating Engineering.

This formed the subject of the address of the President, Prof. A. E. Kennelly, who, however, was himself unavoidably absent at the International Electrical Congress in Turin.

In a previous address Prof. Kennelly has dealt with 'The Profession of Illuminating Engineering.' On this occasion he selects for consideration *the measurement of light*.

Every department of science, he points out, takes its origin in a collection of scattered observations. It is only gradually that the connexion of these facts becomes apparent and definite and invariable laws are ascertained. The establishment of precise quantitative relations is a still later stage. The highest development in a science is that in which all the laws are recognized and are exceedingly simple so that they may be reduced to the operations of simple arithmetic.

The measurements involved in illuminating engineering are mainly photometric. The precision with which a standard illumination can be reproduced is, however, still comparatively small. Great progress has been made in the direction of using incandescent standard lamps, but should all these lamps be destroyed simultaneously, it would be difficult to reproduce them with any exactitude.

When we come to the question of the absolute measurement of light, and the luminous equivalents of radiation of different parts of the spectrum, we are faced with grave physical and physiological difficulties. The fact that the eye perceives light in quite a different manner at very low illuminations from what it does with strong lights and the problem of comparing lights of different colours render this matter a very complicated one. A good start has been made in the investigation and tabulation of information on these points, but there is still very much to be learned.

All research connected with photometry borders on the work of ocular physiology and psychology. Consequently all such research, in order to be effective, should be undertaken with adequate information concerning what has already been done in these directions.

Since it has probably taken millions of years to develop the human eye from the first patch of somewhat radiantly active skin of a remote and primary progenitor, it is not wonderful that the study of the eye should be so difficult. On the contrary is it not wonderful, rather, that from a broad optical standpoint the physical mechanism of the eye should be so easy to comprehend ?

It might at first be thought that the knowledge, in a few laboratories, of certain physical-physiological constants for the human eye was of no importance to the broad industry of illumination, in the manufacture, engineering, distribution, or sale. Nevertheless, it may well be contended that, on the contrary, all such knowledge is of great importance to the industry in many ways.

In the first place, disputes tend to vanish when the matters in dispute are

properly known to a specially trained few, even though the facts may be out of the line of vision of the many.

In the second place, all such knowledge rapidly begets applications, improvements, economies, in a manner of which modern experience affords many examples.

Report of Sub-Committee on Photometric Units.

The following is the report issued by the sub-committee on photometric units :—

As instructed by the 1910 convention, the sub-committee on photometric units endeavoured to get in touch with foreign authorities on the question of photometric units, with a view to paving the way for future agreement on these questions, taking the progress report of 1910 as a basis. With that in view the chairman of the sub-committee has communicated with the following gentlemen in foreign countries :—

Mr. C. C. Paterson, of the National Physical Laboratory, London.

Mr. A. P. Trotter, of the Board of Trade Standardizing Laboratory, London.

Prof. Silvanus P. Thompson, President of the British Illuminating Engineering Society, London.

M. F. Laporte, Laboratoire Central d'Electricité, Paris.

Prof. Eric Gerard, Director of the Montefiore Institute, Liège.

Mr. Ormond Higman, Chief Electrical Engineer, Electrical Standards Laboratory, Ottawa.

Replies have been received from Messrs. Gerard, Trotter, Higman, and Paterson. Mr. Trotter objects to the designation of the intensity unit as " candle " rather than " candle-power," but otherwise approves of the report. Mr. Higman expresses his sympathy with the work of the committee, but doubts the desirability of using the letters I, E, R, C, and L, for photometric units inasmuch as they are used to express other physical quantities. Mr. Paterson has submitted a number of very valuable suggestions which are at the present time before the committee for its consideration. In addition, M. Blondel, a member of the sub-committee has undertaken actively to interest scientific bodies in France in the approval of last year's report and has taken up the matter with the French Physical Society and with the Society of Electricians. The sub-committee is greatly indebted to M. Blondel for the work which he has done, and is doing, in this direction.

It will be seen that the progress during the year has been slow, yet some foundation has been laid for future activity, and no rapid progress is to be expected in negotiations of this character. The report of the committee has frequently been referred to in the foreign technical press and has thereby attained considerable publicity abroad.

The committee would make the following recommendations :—

That the term " lighting " be used to designate the product of luminous flux by the time, the symbol therefore being " L." The " L " then would displace the " O " used as a symbol for this quantity in the 1910 report.* The committee would further recommend the adoption of the following symbols :—

Mean spherical candle-power, $I\,\theta$.

Mean upper hemispherical candle-power, $I\,\underline{\triangle}$.

Mean lower hemispherical candle-power, $I\,\underline{\triangledown}$.

Total flux, $F\,\theta$.

Upper hemispherical flux, $F\,\underline{\triangle}$.

Lower hemispherical flux, $F\,\underline{\triangledown}$.

These symbols have been proposed by M. Blondel and differ but slightly from those used in Germany, the bar being carried a little beyond the circle on each side. The idea is that the symbols will be less liable to confusion if this form is adopted.

The committee would further recommend that negotiations with individuals and societies in other lands be carried on with a view to the possibility that eventually this society will arrange for an international conference to bring about an agreement on these subjects.

A communication bearing on this report was presented by Dr. A. S. McAllister, who drew attention to the

* *Illum. Eng.*, Lond., Feb., 1911, p. 74.

confusion apt to be introduced by using the English alphabet letters for both electrical and photometric units. Some of the letters suggested in the report were already alotted to electric quantities, and he advocated the use of Greek letters so as to remove any confusion on this point.

PHOTOMETRY AT LOW INTENSITIES.

The paper by Dr. Louis Bell on this subject pointed out the difficulties of photometry at very feeble illuminations. When an illumination of the photometer screen of 20 to 30 lux is obtained an accuracy to within 1 per cent is possible but when the illumination is below 1 lux, and still more when it falls under 0·25 lux, the readings become much wider apart.

An important point to be noted however, is that the value of "Fechner's fraction" (*i.e.* the percentage change in brightness just perceptible to the eye), which is ordinarily exceptionally high at low illuminations, becomes very much less if the eye is allowed time to accommodate itself to the darkness. This change corresponds with the regeneration of the visual purple. This "dark-adaptation," however, is very readily spoiled by the presence of even a moderately bright light within the field of view. Little is known regarding the extreme limits to which this dark adaptation might lead us; but as a result of only ten minutes rest in the dark quite surprising effects can be secured.

The author gives a curve showing the change in the sensibility of the eye that takes place when the eye is allowed to regenerate itself in darkness.

The practical bearing of this is also shown by a curve connecting the sensitiveness of the eye and the illumination given to the screen of a Lummer Brodhun photometer; this closely resembles that given by other observers before the Illuminating Engineering Society in this country.* The chief point to be noted is the rapid decrease in sensitiveness below 0·25 lux; this is considered to be the point at which "cone-vision" is replaced by "rod-vision."

* *Illum. Eng*, Lond., April, 1910, p. 237.

Dr. Bell also mentions some experiences which support the conclusions of Prof. Burch, of Oxford University, who states that if the eye is allowed to rest for a sufficient time in perfect darkness the sense of colour, originally extinct, re-appears once more.

THE PHOTOMETRY OF LARGE SOURCES OF LIGHT.

Another very interesting paper on photometry was that read by Mr. G. H. Stickney and S. L. E. Rose on the testing of large light sources.

The paper details some of the methods used in the laboratory of the General Electric Co. at Schenectady. The authors are concerned mainly with methods of securing polar curves of light distribution; they divide apparatus for this purpose into three classes namely constant length, constant intensity, and constant radius photometers. These names refer to the manner in which the illumination on the photometer screen is varied. In the "constant radius" type the photometer is kept still and the distance of the standard lamp is varied. This is the best plan in the case of reflectors, &c., when it is uncertain where the "centre of radiation" of the source is really situated.

Among the types of apparatus described they include the form, resembling that of Prof. Matthews, in which a series of mirrors is utilized. Another method is to use two inclined mirrors, in a somewhat similar manner to that employed and described by Prof. J. T. Morris. In this case the photometer its kept stationary and the standard moved. A revolving sector disc is also employed so as to enable the enormous variation in brightness at different angles from flame arcs to be determined.

The laboratory also makes use of Reference, Substitution, and Working standards, 40 watt and 250 watt tungsten lamps being employed. Data sheets on which full particulars regarding the performances of lamps tested are systematically entered are also used and examples of these are given by the authors in their paper.

In conclusion some remarks are made

on the peculiarities of lamps that call for consideration from the photometrist. The greatest difficulty is the fluctuations in light of many of these sources; this leads the observer to get results which depend on his personal idiosyncrasies; many such lamps are apt to be rated too high, judging from their *mean* intensity.

Legislative Enactments on Illumination.

Mr. E. L. Elliott contributed a paper summarizing the legislation of various countries on the subject of illumination. He describes the aims of the American Association for the Conservation of Vision and gives an account of the co-operation received from various organizations in the United States. He next proceeds to summarize existing European legislation, referring to the Congrès International des Maladies Professionelles, &c., as previously dealt with in this journal. He also quotes a passage from the *American Legislative Review* showing that various states in that country specify that interiors should be "well lighted," "well and sufficiently lighted," or "reasonably well lighted" throughout working hours," &c., the recommendations, however, being in general terms. Finally, he alludes to the announcement of the formation of a Committee to study the hygienic aspects of French Government lighting, also recorded in these columns.

What is now needed is a convenient and simple instrument for measuring illumination in factories. The requirements of such an apparatus he states to be as follows :—

1. Absolute Portability. It must be as easily carried as the larger sizes of photographic cameras of the Kodak order.

2. An accuracy in the hands of a non-technical and inexperienced user of not less than 10 per cent.

3. Moderate Cost.

In conclusion Mr. Elliott refers to an interesting instance of pressure brought on employers to reform their lighting. Two years ago there was a great strike in the suit, cloak, and skirt industry in New York for more sanitary conditions of labour. In the settlement it was agreed that a sanitary board should be appointed to deal with these questions, and the advice of a number of specialists, including a lighting engineer was sought. As a result a code of recommendations was issued, and in reference to lighting it was advocated that :—

Halls and stairways leading from shops to be adequately lighted by natural and artificial light.

Sufficient window space to be provided for each shop, so that all parts of the shop will be well lighted during the hours from 9 a.m. to 4 p.m.

All lights to be well shaded, to be placed above operators and not too near them.

The Distribution of Brightness in Nature.

The paper by Dr. H. E. Ives and M. Luckiesh on this subject deals with daylight illumination in a strikingly novel way. The authors point out that it is still an open question how far, in artificial lighting one ought to imitate daylight. Even assuming that it is desirable to do so, however, the question remains what are the characteristics of daylight that we ought to imitate ? For in nature widely different conditions, not all of them pleasing, exist.

In order to obtain evidence on this point, the authors have adopted the novel method of taking photographs of various landscapes, &c., under different climatic conditions, studying the distribution of brightness, and observing when the general effect is pleasing or the reverse. But in order to preserve a photographic record of brightness, it is necessary to use a plate and screen of such a kind as to observe and record the brightness of light of different colours in exactly the same way as the eye. By the use of a special screen coloured with rhodamine, tartrazine, napthol green, and aesculin, the desired conditions in this respect were obtained a photograph of the spectrum varied in density in exact proportion to the brightness of the different portions as seen by the eye. The authors also describe special apparatus employed

to extend the natural range of view of the camera lens.

A series of different outdoor views are presented, and the authors endeavour to draw general conclusions as to the conditions of brightness that appear pleasant and disagreeable.

Nature, they point out, is far from uniformly agreeable to gaze upon. Very short shadows, such as exist at mid-day seem undesirable. The same scene, which by the light of the sun overhead appears glaring and ugly becomes most attractive in the early morning or late afternoon. Similarly completely overcast skies do not give pleasing results on account of the monotony of the foreground. An intermediate condition seems preferable. It is to be noted, however, that the overhead method of lighting, which in nature is the least satisfactory, is that usually employed for artificial illumination.

Other suggestions thrown out are that the eye will tolerate a greater brilliancy above the horizon than below, but that it objects to large areas of nearly uniform brightness.

In conclusion the authors give some data on the surface-intrinsic brilliancy of various objects in nature.

Blue Sky	2·2	c.-p. per	sq. in.
Cumulus Cloud	10·4	„ „	„
Overcast Sky	3·3	„ „	„
Dark Overcast Sky ...	1	„ „	„
Cement pavement illuminated by sunlight ...	6	„ „	„

The ratio between the brightest and darkest point in the average landscape is about 20 : 1.

Recent Advances in Incandescent Lamps.

Mr. J. E. Randall sums up the improvement in quality of electric incandescent lamps during the last few years.

Naturally he lays stress on the production of ductile tungsten. This material was being considered in 1907, but it was not until the present year that it was produced on a commercial scale. An important item has been the gradual elimination of traces of carbon in tungsten lamps. Up to a certain point traces of carbon lead to brittleness and they also cause the filaments to shrink when used. To allow for this shrinkage it was formerly necessary to make the filaments very slack and they were naturally inclined to sag. Nowadays a great improvement in this respect has been made. The drawn wire filament is stated to be to all intents and purposes pure tungsten. The structure of the filament is originally fibrous, but it gradually becomes crystalline during the burning life of the lamp. There is, however, no "offsetting" either on direct or alternating current. Another important quality of drawn wire is the variety of size possible. Filaments can be drawn to take as much as 6·6 amps. for series lamps, and as little as 0·2 amps. It can also be readily wound into special shapes : helices, zig-zags, &c.

In conclusion the author raises the interesting question whether carbon may not eventually be produced in a form as good as tungsten for incandescent lamps. The variety so far obtained in the metallized filament is promising.

Small Gaslighting Units.

Mr. F. H. Gilpin draws attention to the fact that whereas in the case of electricity lamps giving 8, 16, 32 c.-p., &c., have been available, the lowest nominal candle-power obtained from incandescent mantles was 50. The advent of metallic filament lamps has tended to raise the standard of candle-power in electrical engineering ; recently also small gas mantles of the "midget" type, giving 25 M.Sph.C.P. have been introduced, so that both methods of lighting now enjoy nearly the same facilities in this respect.

The author gives a series of tests of these small lamps, efficiencies from 15 to 27 c.-p. per cubic foot being recorded according to the pressure ; a noticeable fact is that the smaller candle-power mantles yield the highest efficiency. Most of these mantles decrease less than 20 per cent in c.-p. during a test of 1,000 hours, a loss which includes the soiling of the glass globes.

Illuminating Glassware.

A novel departure in this direction has been made by the presentation of a series of papers by different authors

each dealing with the section of the subject with which he is most familiar; the whole is intended to form a complete review of present knowledge on lighting glassware.

Mr. W. Bassett Jones, in a preliminary note, explains the object of this series of papers and adds that it is hoped to supplement them by a corresponding collection of data on metal reflectors. He also draws attention to the important place now being assigned to the decorative and artistic design. The feeling is growing that devices which yield light must also be in themselves pleasant to see.

In the present occasion five papers are presented. Mr. E. H. Bostock deals with the manufacture of glass for illuminating purposes, Mr. F. L. Godinez discusses the principles of Reflector Design, and Messrs. McCormack, Marshall, and Young give accounts of the work of three factories in which illuminating glassware is made.

Mr. Bostock's paper serves to show the extraordinary variety of glass, both as regards colour and diffusing properties which can now be obtained. It is the illuminating engineer's duty to study these varieties and learn how the best use can be made of each. For a long time the whole process of glass making has been a mystery to those not immediately concerned with its production, but the distance between the manufacturer and user of glass has been greatly reduced by the agency of the illuminating engineering movement.

Glasses may vary in colour, in opacity and in polish; the one common quality of all good glasses is that they are amorphous in structure. Taken as a whole glasses may be regarded as "structureless solids." In order to avoid the setting up of a strain in the glass (which would spoil the uniformity in refractive power) very gradual annealing is necessary.

At the present time it is possible to give molten glass almost any colour. An interesting point to be noticed, however, is that there are two distinct ways in which this colouring takes place; either the colouring matter is taken up as a true solution or it is suspended in "colloidal solution," *i.e.*, distributed small particles such as can be seen to be separate under the microscope. This naturally affects the degree of absorption. For the rest, copper can be used to secure reds and greens, tin oxide, aluminium fluoride, and other materials produce opal, cobalt, blue, and chromium salts, green, pink, and purple, &c.

Mr. Bostock makes some remarks on methods of diffusion. Very often a softer finish than sand-blasting, light acid etching, or satin-finish, for example, is desirable. Prismatic glassware has great advantages. There is also a variety of diffusing glass known as "phosphate"; this enables good diffusion to be obtained without the aid of sand-blasting, which accumulates dust, or opal, which absorbs an undue amount of light.

In conclusion illuminating engineers are urged to study more closely the variety of coloured glass they need for specific problems. Many beautiful decorative schemes have been spoiled by light of the wrong value or globes whose surface colour by daylight was not in harmony with the room. "Let the engineer study the problem carefully and if the glass colour he needs is not found at once he should go on looking and asking until he gets it."

Mr. F. L. Godinez in his paper on Reflector Design, also lays stress on decorative appearance. Manufacturers have not paid sufficient attention to this point; in shoplighting, for example, the decorative appearance of a tasteful lighted shade, harmonizing with the rest of the window, adds greatly to the effectiveness of the whole display.

The author has been studying the nature of transmission through many forms of shades. By means of the ultra-microscope, photographs are obtained showing that ground and etched glass really consists of very fine, but isolated, opaque particles. The nature of such surfaces is now becoming of consequence because of the growing conviction that the intrinsic brilliancy of modern illuminants invariably demands some form of shading.

Mr. Godinez also contends that from the decorative standpoint a slightly

tinted rose or amber shade, even though the colouring entails a certain sacrifice of light, is often desirable.

In the case of reflecting glassware the author considers, a certain amount of diffuse reflection is desirable. Polished glass is apt to give rise to a streaky effect even if used with frosted bulbs. The defect is mitigated by giving the reflector a satin finish, and can be entirely removed by means of an opal reflector with a polished inner surface. Mr. Godinez gives examples of forms of reflectors in which this principle is applied, accompanied by distribution curves.

He sums up by declaring that the qualities which are desirable in illuminating glassware are "reliability, efficiency, artistic appearance, and above all the elimination of glare."

Mr. C. H. McCormack also deals with the question of depolished reflectors, and reproduces side by side the polar curves of light distribution from a polished and depolished variety. The curves are almost identical but the depolished surface is stated to reduce the streaky direct reflection characteristic of the polished variety.

The author also inveighs against the rule of producing uniform illumination under all circumstances. Monotony in this respect and also monotony in design should be avoided. By moulding the outsides of these depolished white reflectors a highly decorative appearance is said to be obtained.

Mr. A. J. Marshall presents what is the longest and most comprehensive paper of the series. The development of HOLOPHANE GLOBES AND REFLECTORS is traced from its commencement. He gives a complete series of illustrations of all the existing types including the assymetrical, satin finish, and combination reflectors of the Street-lighting variety, in every case giving with the illustration the appropriate polar curve. He also gives some interesting particulars regarding the way in which the moulds for these globes and reflectors are made and stored.

Mr. L. W. Young deals with another variety of glassware, the "ALBA" GLOBES. These utilize a variety of glass which is said to have excellent diffusive properties. He describes it as white in texture, and unpolished, but not coarse and rough as a sand-blasted surface would be; it is not so dense as opal and does not possess the same surface reflection. It is stated that by glass of this kind a very good distribution of light in the lower hemisphere can be obtained. The amount of light absorbed by the "Alba" globe is given as 13·5 per cent. Some ornamental fancy urns and other special fixtures for interior inverted lighting are reproduced.

THE EFFECT OF SURROUNDINGS ON ACUTENESS OF VISION.

We come now to several papers on general problems. Mr. J. R. Cravath raises the question how far the ability to read in comfort with a certain illumination depends on the nature of the surroundings. Ought these to be bright or dark? And is a purely local or a widely distributed illumination best?

The present data on these points are somewhat conflicting. It is admitted that bright lights in the field of view have ordinarily the effect of making vision more difficult. On the other hand, some observers also maintain that brightly illuminated and light tinted walls have the same effect and contend that indirect lighting (in which the actual source of light is hidden) should be cautiously applied on this account.

Another difficulty lies in deciding from personal experience what constitutes a "comfortable" illumination. Different people have sometimes quite distinct ideas on this point, and more data are needed to distinguish abnormal requirements from those of the average individual.

Mr. Cravath has therefore carried out a series of tests on eleven different individuals, various methods of lighting being used, and the "minimum" and "comfortable" illumination for reading being given in each case.

From these results he concludes that the all important fact (in addition to the absence of the sources of light themselves in the field of view) is the avoidance of the direct glare off the more

or less shiny paper. An essential point, therefore, in lighting schemes, is that light coming from all directions on the paper should be aimed at and not purely local lighting. This last method, when used alone, has several drawbacks; firstly, it tends to cause direct reflection from shiny material, secondly, the use of opaque reflectors placed low down produces a brilliant local illumination, but leaves the rest of the room in comparative darkness—a state of things which is believed to be trying to the eyes.

According to these results obtained for different classes of type, the personal equation would seem to be of importance. For example, one observer considers 0·5 foot-candles a minimum and 0·75 foot-candles ample for a certain type; another observer under the same conditions demands 7 and 10 foot-candles respectively. Probably both these observers may be considered abnormal. Our aim must be to provide for the average person. The mean results for this type, for the 11 observers referred to above, work out to about 1·8 foot-candle minimum and 3·5 ample illumination.

Other General Papers.

Of the other papers that by Messrs. Ward Harrison and G. H. Magdsick dwells upon the need for more exact data on the conditions of illumination obtained from various installations in actual operation. "To calculate the initial illumination to a high degree of accuracy when the average performance is oftentimes not known within 25 or 50 per cent seems an unnecessary refinement." It is very difficult for the private individual to have to bear the expense of adequate tests of different systems. Corporations, however, carry out independently such researches, and there is a great waste in useless duplication of material.

There ought, they suggest, to be some means of bringing these data together and tabulating them. Among the questions which render such comparisons difficult, however, is the want of a uniform method of expressing the light from a lamp (*i.e.*, whether in horizontal, spherical, or hemispherical candle-power), and also the fluctuations in intensity of many sources.

Dr. A. S. McAllister contributes a mathematical investigation into the distribution of light from linear and surface sources of light.

Mr. F. B. Rae pleads for more simple and practical rules and data on illumination which will be better appreciated by the general public.

Mercury Vapour Lamps giving White Light.

By an Engineering Correspondent.

The first mercury vapour lamp was exhibited in January, 1902, in the entrance of the Engineer's Club, New York. Its appearance excited much curiosity; it was felt that this large luminous element, shedding soft diffused light, marked the entrance of a new system of lighting into industrial life, *i.e.*, the incandescence of rarefied gases, which, until then, had been largely an object of curiosity, in the form of Geissler tubes.

Unfortunately, the light emitted by these tubes was entirely deficient in red rays.

The light emitted by incandescent mercury vapour is composed of a small number of visible radiations; one yellow ray of a wave length of $\lambda = 0{\cdot}578\mu$ one green ray $\lambda = 0{\cdot}546\mu$ one blue ray $\lambda = 0{\cdot}436\mu$ one violet ray $\lambda = 0{\cdot}404\mu$, and a certain number of ultra-violet rays, of which only one, of a wave-length of $0{\cdot}366\mu$, traverses the glass of Cooper Hewitt tubes.

The colours of all objects exposed to the light were consequently greatly modified, particularly those of the human face, which appeared livid, the white tints being apparently yellow-green and the

red tints blue-black. The use of the Cooper Hewitt lamp was therefore limited. It was debarred from the lighting of dwelling houses, shops, dye-works, and other premises where articles were sorted according to colours. On the other hand, large metal works, engineering workshops, weaving mills, and tramway sheds discovered decided advantages in the economy and diffusion of this light.

Mr. Cooper Hewitt at once occupied himself in the improvement of the colour of his lamp.

At first attempts were made to combine this spectrum with that of a body rich in red radiations, in such a manner as nearly to reproduce white light. All bodies with a suitable spectrum and which attacked neither the glass nor the electrodes have been tried, but without success. Gases were first employed, but the trouble was that the gas and mercury spectra could not be obtained simultaneously. For example, a tube with a mercury cathode, simply filled with nitrogen, was plunged into ice; it appeared pink; but as soon as it was removed from the ice it was filled with the mercury vapour and became *green*. The spectra of nitrogen or mercury always preponderated. Various gases have been substituted for nitrogen, in particular argon and helium. The result has always been the same. It seems, therefore, that the conducting medium is, according to circumstances, the ions of one or other of the gases or vapours filling the tube; by no means can a combined spectrum be secured.

Subsequently metallic ingredients were added, for example, the mercury was replaced by an admixture of potassium. But now in a tube 1 metre long, the upper part became red and the lower part green, the change of colour being produced over a length of about 2 cm. In short, it appears to be impossible to super-impose, in a practical manner, the spectra of different bodies in vacuum tubes.

It is true that Heraeus succeeded in preparing for spectroscopic studies, an amalgam lamp of quartz. This lamp contained a mixture liquid at ordinary temperature, formed of 60 per cent mercury, 20 per cent lead, 20 per cent bismuth, to which was added about $\frac{1}{2}$ per cent of zinc and $\frac{1}{2}$ per cent of cadmium. It is even possible to add thallium and antimony. But, to the eye, this lamp appears to give the same light as a pure mercury lamp.

The failure of these attempts showed that it was necessary to produce the red rays which were lacking *outside the tube*. One of the first methods consisted in adding to the tube another luminous source rich in red rays, such as incandescent carbon filament lamps. This, however, also resulted in a source which was inconveniently complicated. On account of the relatively low efficiency of the incandescent lamps, a luminous efficiency considerably below that of the Cooper Hewitt tube alone, was obtained and one of the principal advantages of the use of the latter thus partly disappeared.

There is nothing to hope from a reflector simply coloured red, or from a red screen, because these are only affected by the red radiations in the source added to the mercury lamp. On the other hand the phenomenon of fluorescence offered a solution of the problem. Certain substances have the faculty of absorbing radiation of a certain wave length (exciter rays) and transforming and emitting it as light of a different colour (excited rays).

In a general way, excited rays have greater wave lengths than those of exciter rays, but they vary with the nature of the fluorescent substance and the excitant. Fluorescence is principally produced by the highly refrangible blue, violet, and ultra-violet radiation. Now the spectrum of mercury vapour being very rich in rays of short wave-length, might be expected to furnish exciter rays in a large quantity.

Fluorescence is always accompanied by absorption; it can, in fact, only be generated from a given supply of energy (in the present case, that of the excited rays) at the expense of some other form of radiation (that of the exciter rays). This transformation naturally occasions a certain loss and the total energy returned is less than the total energy received. However,

in the case of mercury, it was permissible to expect a sufficient utilization of the ultra-violet rays which although invisible to the eye, are very potent in exciting fluorescence; this circumstance would compensate in part for the loss of light by absorption. Indeed, it might even be poss ble for the transformation of the light from Cooper Hewitt tubes to be effected without diminishing the total intensity of the visible spectrum.

The intensity of the excited rays depends equally on the fluorescent substance employed; a solution of sulphate of quinine, for example, emits blue rays, whilst a solution of fluorescein will emit bright green rays.

The first tests in this direction were made by surrounding Cooper Hewitt tubes with gauze veils of rhodamine dye. The transformation was fairly good, but the quantity of light absorbed was too great and the efficiency poor; furthermore the phenomenon of fluorescence was not satisfactorily manifested by transmitted light.

Fluorescence is a phenomenon produced near the surface of bodies. This arises from the fact that the first layers absorb the exciter rays; none of them reach the deeper layers. On the other hand, the majority of fluorescent substances have very marked bands of absorption, so that, in acting by transparency there is the risk of suppressing certain rays in the complete spectrum which it is desired to retain.

It is therefore better to place a reflector behind the tube. By varying the dimensions and the form of this reflector, it is possible to vary the relation of the quantities of light which reach the eye directly from the tube, or after reflection, in such a way as to receive approximately, the impression of white light.

The fluorescent substance employed by Mr. Cooper Hewitt is still rhodamine. Rhodamines are artificial substances of the phthalein class; rhodamine itself being phthalein of metaamidophenol. The solution in water or spirits is pink, and possesses in daylight a magnificent orange fluorescence, which is even better in acetic solution.

If a continuous spectrum is thrown on to the solution it will be seen that the rhodamine absorbs the yellow and the green, in the visible spectrum, but allows the red and the blue to pass. Consequently surfaces coated with this material appear *pink* by reflected light. Absorption commences again in the violet and ultra-violet. Fluorescence corresponds entirely with the nature of absorption; the light due to the fluorescence is red throughout the whole of the spectrum, both for the ultra-violet and the visible rays; similarly in the case of barium platino-cyanide, where the light emitted is always green.

It can readily be understood what happens in the case of the mercury lamp. The band of absorption of rhodamine has its mean situated about 0·555 μ (green); the yellow ray 0·578 μ and the green ray 0·546 μ of mercury are absorbed and the light emitted is red; the blue ray 0·436 μ does not excite any fluorescence, the light reflected having in this case almost exactly the same colour; it is only a little more mauve. The violet ray 0·404 μ also gives rise to red fluorescence, and the ultra-violet rays (0·366, 0·313, 0·254) are specially active in this respect; the first, 0·366 μ, is the only one emitted by Cooper Hewitt tubes, the glass absorbing all the others.

It can be seen that rhodamine fully answers the desired end; it transforms a portion of the yellow and green radiations (the most intense) into red; it even utilizes the ultra-violet radiations.

Unfortunately, rhodamine, like fluorescein and eosine, which it resembles chemically, is not very permanent to light. A screen simply dyed rhodamine loses its effect after twenty-four hours' exposure to mercury light. It was necessary to incorporate the rhodamine with a body which rendered it more durable, and it was also essential that this body should be transparent, so as to permit the light to act completely on the rhodamine. After a great number of tests, such a material was found. A coloured solution is coated on a paper screen; and although the manipulation is complicated, it is possible by this means to obtain paper

screens dyed rhodamine, which serve as reflectors for Cooper Hewitt tubes.

The light reflected by the complete reflector and tube instead of being of the colour of the tube alone possesses a beautiful white tint (even slightly pink). The colour of the face as seen by this light, is normal, and materials exposed to daylight, and then to this complex light, do not appear to undergo any noticeable change.

The discovery of Mr. Cooper Hewitt therefore possesses a great technical interest, being regarded as the first really practical application of fluorescence. It should also prove of great practical value in facilitating the use of mercury vapour lamps for general lighting.

Effect of Mercury Vapour Lamps on Eyesight.

SOME interesting experiments on this point have been carried out in the United States by Dr. C. H. Williams, M.D.* He gives an account of investigations of twenty-eight cases of people who habitually used these lamps, including :—

1. Eight cases of men who worked all day under unusual conditions of exposure to the light.
2. Twelve cases of draughtsmen who have part of their work by daylight and part under the mercury lamps.
3. Six cases of Garage employées who work at night with the lamps.
4. Two cases of women who work all day with the light in a photographic printing room.

In summarizing the results of these tests the author remarks :—

"The fact which stands out most distinctly is that in no case does a careful ophthalmic examination show signs of trouble with the optic nerve or retina, which cannot be more properly attributed to other causes....In no case was any change found inthe crystalline lens or the transparent media of the eye."

The only noticeable effect appears to have been a tendency to colour fatigue, which was clearly observable after leaving work with the mercury lamp. There appeared to be tiring of the green sensation, but the author suggests that this is a temporary effect.

* *Elec. World*, Sept. 2, 1911.

[The question raised by Dr. Williams is an interesting one, but we should like to see his conclusions confirmed by corrobarative tests by other investigators, preferably extending over a longer period of time.—ED.]

Electrical Exhibition at Brighton.

THE Brighton Corporation was one of the earliest Municipal authorities to establish an electricity department. We understand that the history of the undertaking has been an exceptionally prosperous one, and in 1905 a large new power house at a cost of £350,000 was officially opened by the Right Hon. John Burns, President of the Local Government Board. The illumination of the sea-front with arclamps has always been a prominent feature and during the Coronation celebrations festoons of incandescent lamps, extending the whole 3½ miles were added; there were also decorative displays on the piers.

With a view to keeping the inhabitants fully informed as to the varied applications of electricity for illuminating, cooking, heating, and power purposes, Mr. Christie, the Engineer and Manager of the Electricity Department, has organized an exhibition which opened in the Brighton Aquarium on October 28th for two or three weeks, when a representative selection of all the latest novelties was on exhibition. We hope to be able to give our readers some particulars of its most interesting features in a subsequent issue.

The Lighting of the Westminster Public Library.

A CORRESPONDENT sends us some interesting particulars of the system of lighting adopted in the Westminster Library. This is said to have been the first library erected in London under the Public Libraries Act, and the illumination has been the special care of its librarian. Quite recently the installation has been considerably altered, tungsten lamps and Holophane reflectors being substituted for the carbon filament lamps previously employed, and the conditions of illumination have been closely studied by Mr. Frank Pacy, the Librarian, by whose courtesy these particulars were obtained.

In the Lending Room, where all inquiries at the counter by visitors are made, a bright general illumination of 3-foot candles is provided. In the various reading rooms, on the other hand the chief intention is naturally to direct the light on the racks and tables.

Fig. 1 refers to the Ratepayer's Room (a small room set apart for ratepayers only).

The chief requirement is that there should be no glare to offend the eyes of readers, and that ample illumination should be provided on the tables, which are lighted by four 25 c.-p. tungsten lamps equipped with concentrating Holophane reflectors. A person seated at the tables is not even conscious of the filament of the lamp. The illumination proved on measurement to be as much as 4·5 foot candles. It might have been supposed that in order to secure such a relatively high figure as this the consumption of electricity would also have been high. The consumption for this room, however, is only about 0·5 watts per square foot of floor area. The explanation naturally lies in the fact that the great majority of light is directed where it is needed—on the tables. Yet quite sufficient has been allowed to the walls, and the room does not appear sombre or unduly dark.

The Newspaper Room (shown in Fig. 2) is considerably larger. It is lighted by two rows of 32 c.-p. lamps with Holophane stiletto reflectors and one row of 50 c.-p. lamps similarly equipped. This last row not only illuminates the newspaper racks in the middle of the room, but also those at the side (not seen in the figure) and a higher candle-power was therefore necessary. The arrangement of the lamps with respect to the news racks makes it virtually impossible for the eyes to be troubled with glare ; not only are the filaments concealed by the reflector, but they are also out of the direct line of sight of the reader. The polar curve of light distribution of these reflectors is specially suited to the sloping racks, and the illumination from top to bottom, nearly 3 foot-candles, is exceedingly even. The consumption of electricity for this room is also remarkably low, being considerably under 0·5 watts per square foot of floor area.

To sum up, it appears that the installation is well arranged both from the illuminating engineering and economical standpoints, and we understand that the contractors were Messrs. Speedy, Eynon & Co.

FIG. 1.—Westminster Public Library: Ratepapers' Reading Room.

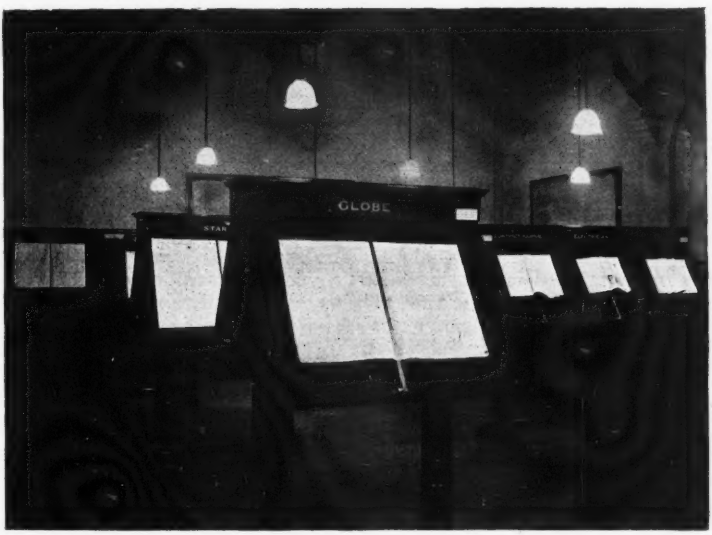

FIG. 2.—Westminster Public Library: Newspaper Room.

An Artistic Interior Lighted with Tungsten Lamps and Silk Shades.

THE illustration on the opposite page shows an exceptionally artistic drawing-room which is illuminated by tungsten lamps in silk shades. The method is of considerable service when a soft and subdued illumination is desired and economy is not an important factor.

The photograph, which was taken entirely by artificial light, gives a good idea of the general effect, but hardly does justice to the decorative appearance of the shades themselves. Owing to the long exposure necessary to bring out the details of the room and darker parts of the surroundings, an exposure of as much as 45 minutes was found desirable; consequently, the illuminated shades, which are so much brighter than their surroundings, are naturally somewhat over-exposed, and the pattern upon them is not brought out. It may be noted, however, that there is practically no "halation" of the shade—no appreciable spreading of the image, and the result is probably as good as could be obtained in the circumstances without having recourse to retouching. The exposure was determined by the Holophane Lumeter apparatus, as explained in a recent article in this journal.

The distribution of brightness on the floor, walls, and ceilings is well represented. The illumination over the tables in most parts of the room is only of the order of $\frac{3}{4}$ of a foot-candle, which many people would doubtless consider insufficient for reading; on the other hand, the effectual protection of the bright filaments by the silk shades, and the comparatively subdued nature of the surroundings, no doubt makes it possible for a lower illumination to be used than might otherwise be found necessary.

The photograph, it will be noted, is successful in bringing out the bright circles on the ceiling where the light escapes through the apertures at the top of the cylindrical shades; this unevenness seems a blemish from the lighting and artistic standpoints, and might possibly be avoided by introducing some form of diffusing reflector at the top of the shades. Besides smoothing out the uneven contrasts on the ceiling, this would doubtless have a beneficial effect in strengthening somewhat the downward illumination on the tables.

The Illuminating Area of School Windows.

THE problem of the school window is dealt with in a short note in the *Medical Officer*. From the point of view of satisfactory ventilation, it is suggested that the ordinary double-hung sash window serves very well, especially if a hopper frame is fixed on the inside to prevent undue draughts in the winter.

A serious objection to the sash-window, however, is the large amount of woodwork in it, which considerably reduces the illuminating area. The conclusion arrived at is that a combination of side-hung casement and hopper panes would be the most effective. By this means practically the whole of the window can be opened if required, the adaptability to varying weather conditions is considerable, and the primary function of the window, *i.e.*, to illuminate the interior effectively, is not interfered with.

Illumination Required for Various Purposes.

SINCE the publication of an article on the above subject in our last issue, some additional information has come to hand, which we now reproduce. The figures (on the next page) are taken from the pages of *Data*, and were originally compiled from bulletins of the National Electric Lamp Association in America.

FIG. 1.—Showing Illumination of Drawing-Room by Tungsten Lamps and Silk Shades.

ILLUMINATION REQUIRED FOR VARIOUS PURPOSES.

	Foot-candles required.		Foot-candles required.
Auditoriums, Theatres	1-3	Offices (when local lighting is used)	1½-2½
Book-keeping	3-5	Post Offices	2-5
Corridors, Halls	½-1	Reading	1-3
Depots, Assembly Halls and Churches	½-1½	Residences	1-3
Drawing Offices	5-10	Stores—Light Goods	2-3½
Desk Lighting	2-5	Stores—Dry Goods	4-6
Engraving	5-10	Stores—Clothing	4-7
Factories (when local lighting is used)	2-3	Shop Windows	5-20
Factories (with no local lighting)	4-5	School Rooms	2-3
Hotel Halls	1-1½	Restaurants, Cafes, &c.	2-5
Hotel Rooms	2-3	Stations—Waiting Rooms	1½-2½
Offices—Waiting Rooms	1½-2½	Train Sheds	1½-2
Offices—Private	2-3	Warehouses	1½-2
Offices—General	3-4		

Artificial Illumination and Scenic Effects in Switzerland.

THE exploitation of the natural beauties of Switzerland has owed much to the science of engineering, and many new developments in railway practice must have originated in this land of mountains. Illuminating engineering is certainly not behindhand in adding to the comforts and pleasures of tourists, and much might be said of the ingenuity and resource which has been displayed in providing even the small villages with their lighting plants, the source of power being in all cases the ever-present mountain stream.

But there are other illuminating effects in evidence, and two of these are perhaps worthy of notice, although some divergency of opinion may be expected as to the desirability of embellishing the natural beauties of the spot in this way. Close to the village of Zermatt is a fine gorge, through which roars a foaming torrent, whitened by the glacier from which it is fed. (Incidentally, it may be remarked that this stream is the source of power for the electric lighting of the village, and with the characteristic care of the Swiss for the beauties of their country, considerable trouble has been expended in preventing the pipe-line, weir, and other necessities of generating by water power, from being unsightly or spoiling the natural grandeur of the scene.)

After duly providing small bridges and gangways fixed to the rocky sides of the gorge, so that its beauties may be accessible to the tourist, it seems to have occurred to the proprietor that his custom might be increased if the gorge were illuminated at night. So electric lamps have been placed in suitable places along the gangways and steps, and hanging from the surrounding trees. The wiring is on the overhead system with bare wires, except where the constant spray from the torrent necessitates specially good insulation. The effect of the illumination is heightened by the use of glow lamps, enclosed in watertight fittings, placed so that their light falls directly on to the foam from the waterfalls, and here and there coloured glass is used to tint the otherwise snowy whiteness of the water.

The other application of illuminating engineering referred to is more in the nature of an advertising device. When walking in the streets of Interlaken in the evening, the visitor will be struck by the glare from the beams of bright searchlights falling on the town from the neighbouring heights. The explanation is that the proprietors of the hotels situated on the summits of mountains overlooking Interlaken, and served by railways from that town, have resorted to the searchlight as a novel and striking way of attracting attention to themselves; at the same time the sweep of the beam indicates how commanding a prospect can be obtained from the windows of their hotels.

Association of Engineers-in-Charge.

THE Association of Engineers-in-Charge held their first meeting of the new session on Wednesday, October 11th, when Mr. W. H. Maw, the newly elected President, delivered his address. Special attention was drawn to the opportunities afforded to engineers of improving the efficiency of the plant and machinery under their charge by attention to small details, such as keeping record of repairs and how they were effected, etc.

We may recall the words of a former President, Mr. Patchell, who stigmatized bad lighting as the worst disease a plant can suffer from.

The Advantages of Automatic Distance Gas Lighting.*

By H. METZGER (Bromberg).

(Abstract of Paper read at the Annual Meeting of the Deutscher Verein von Gas- und Wasserfachmännern June 27-29.)

THERE is perhaps no respect in which gas lighting has made greater progress of late than in the automatic lighting up and extinction of gas lamps in the streets. The great advantage of electric lighting—being able to control lamps from the central station so readily—is now being imitated by the method of controlling gas lamps by a rise of pressure from the works, and favourable experiences of these distance lighters are being reported in many quarters. Certain initial difficulties now appear to be overcome to a great degree, and it is only a question of time before even greater reliability will be secured. Experiments have also been made at Bromberg with clockwork control. But this mechanism did not seem well suited to the climatic conditions and required frequent repair. In addition, the constant winding up is a drawback, and there is always the great additional inconvenience that the control is purely mechanical and takes no account of the existence of fogs and mist; consequently it is not possible to light up earlier on a dull day than on a bright one, as can readily be done when control is exercised from the central station. At present, therefore, this apparatus has not been found suited to public lighting, although it has doubtless conveniences for private purposes, *e.g.*, for the automatic control of illuminated signs, display windows, &c.

An interesting account of some experiments in this direction, was given by Herr Stadtrat H. Metzger, of Bromberg, at the annual meeting of the Deutscher Verein von Gas- und Wasserfachmännern, in Germany. Some people have suggested that automatic control is only suited to towns of relatively small areas. Favourable experience in Bromberg, which has the comparatively large population of 80,000, does not support this view. The most remote lanterns are about 7½ kilometres distant, and parts of the district are about 40 metres above the level of the gas works. Nevertheless the results of the past seven years' experience have been quite favourable.

It will be recalled that methods of controlling gas lamps from the works are based on the application for a few minutes of a rise in pressure in the town mains. This rise in pressure acts on a mechanism in the lantern, commonly by lifting a diaphragm attached to a lever, which turns on the cock and admits gas to the burner. When the time comes for the lamps to be extinguished, a second impulse is again applied to the mechanism and turns the gas off. Apparatus of this kind has been described previously in these columns.

It will be readily understood that the successful operation of the system depends to some extent on the state of the network of mains and the normal conditions of pressure therein. For instance, care must be taken that changes in pressure incidental to the growing evening load do not turn lamps on or off when this is not intended. In Bromberg the pressure at different times varies considerably, being 50–55 mm. of water by day, and 80–90 mm. at night. This increase is needful in order that the more outlying districts should still receive enough pressure when there is a heavy drain on those nearer the station.

In Bromberg there were 1,470 lanterns in use previous to the installation of the automatic system of control, and twenty-two men and one superintendent were employed to keep them

* *Jour. f. Gasbeleuchtung*, Aug. 26, 1911.

in order. The cost of attendance per lantern, inclusive of the wage of the superintendent, was 19.5 m. per annum.

Experiments were first made on a small scale. It must be emphasized that such limited trials, involving as they do, disturbance of the existing organisation without the necessary new arrangements being completed, must be scrutinized with care, for a hasty but unjustifiable impression unfavourable to the change might be formed, which would be corrected when a trial on a larger scale was attempted. It is to be noted, for example, that the innovation is naturally regarded with a certain amount of hostility by the maintenance staff, who see a possibility of their occupations going. Besides this, there were originally defects in technical detail. The consumers complained of the effects of the rise in pressure (which had naturally to be applied to the entire network, although only designed to work the street lamps). Sometimes, too, the rise was so sudden and excessive as to blow the mantles right away from their supports. The considerable percentage of failing mechanisms was also a drawback.

These troubles were partly due to original defects in the apparatus, but also to the fact that the rise in pressure applied was not correct, owing to the local conditions in the network not having been sufficiently studied. Eventually two firms were invited to supply apparatus for trial, arrangements being made for separate streets to be entirely equipped with one and the same apparatus. An agreement was also required, including guarantees :—

1. That the apparatus should work with a pressure rise of 15 mm. at the lantern.

2. That the authorities should have the right to demand the removal of the apparatus and the restoring of the lanterns to their previous condition if (*a*) the needful rise in pressure were more than 15 mm. ; (*b*) the number of rejected pieces was greater than 1 per cent. ; and (*c*) if the maintenance of 800 lanterns required more than four cleaners and two inspectors.

3. Supply at an agreed price.

4. That the cost of the apparatus should be paid within four years out of the saving in wages for attendance on lanterns.

5. That any defect in the apparatus should be made good free of charge during two years.

6. That any defect occurring within five years should be made good at a cost of 80 pf.

Naturally the apparatus is not yet perfect. The experience following the above agreement, however, was sufficiently satisfactory to make clear the great advantages of automatic control and to demonstrate that there was no longer any need to delay in introducing the method throughout the town.

The advantages are considerable. It appears that 800 lanterns can be well served by four cleaners and two inspectors, the inspectors covering the respective districts on cycles each evening, so as to make a note of any defects, and the maintenance men setting matters to rights during the day, including the renovation of mantles and chimneys, and cleaning, when necessary, of the control apparatus.

The duties of the inspectors begin when the lamps are lighted and cease by midnight ; after that time an occasional defect would be of comparatively small consequence. There is also a second inspection when the time for extinction arrives in order to detect any lamps which fail to be turned out. The maintenance men, who are under the direction of the inspectors, have regular hours during the day. This method has answered very well and is not without its social benefit. Previously the hours of attendance on lamps, including lighting and extinguishing by hand and maintenance by day, were so long that the men found it an inconvenience to return to their families in the suburbs each night. A habit grew up of staying at the gas works all night and never going home at all. With the new division of labour there is ample time for both inspectors and cleaners to get free, and this practice has been discontinued.

Among other advantages of automatic ignition may be mentioned the convenience of lighting up and extinguishing the entire series of lamps exactly simultaneously. When they are lighted and extinguished by hand at least half an hour is taken up in attending to the lamps; consequently either the first lamp must be lighted (or extinguished) half an hour too soon or the last one half an hour too late. Besides being unsatisfactory from the lighting standpoint, this leads to an appreciable loss of gas. In Bromberg observations led to the belief that during three-quarters of the year 70,000 cubic metres would be saved.

The number of failing mechanisms, it will be recalled, was specified not to exceed 1 per cent. This is taken to refer either to the time of lighting up or the succeeding extinction of lanterns, *i.e.*, if 1,500 lanterns are in use, the number of failures during both lighting up and extinguishing must not exceed thirty, or 2 per cent.

This is the order of accuracy which may be expected and attained in practice. In Fig. 1 is shown a diagram of the number of failures during several successive months with the Meteor and Bamag types of apparatus. It will be seen that very similar results were obtained, and there is little to choose between them in this respect. In the month of January the percentage was somewhat high, viz., 1·18 per cent, but in the month of April only 0·4 per cent. It is hoped in the course of time to bring the figure lower still.

An exact record is kept of the defects and where they occur. When the percentage in any section of the district is abnormally high the question at once arises whether this is due to a fault in the mechanism or to defective conditions in the mains. By investigating this point defects in the system are brought to light and remedied which would otherwise probably not be detected. In this way the engineer comes to know the distribution of pressure in his pipes much more perfectly than he would otherwise do, and the automatic controller thus acts as an excellent means of locating faults in the system. In Bromberg the rise of pressure is continued for five minutes, this period being found necessary in view of the fact that the sensitiveness of individual mechanisms differs somewhat. If one watches the lighting up of lamps from a height, it is seen that the time taken after the wave is applied is not proportional to the distance away. Lamps light up more rapidly than if this were the case. Sometimes, however, one notices an individual lamp in a row already alight which only becomes kindled much later.

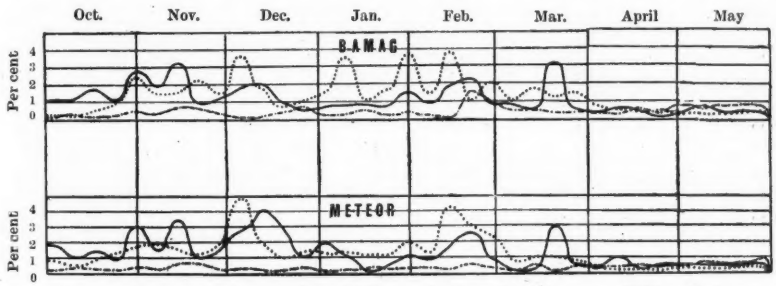

FIG. 1.—Diagram showing number of failures of automatic distance gas-lighters during eight successive months.

——— Failed to light up.
. . . . . Failed to extinguish.
—.—.— Failed from other causes.

The chief possibilities in saving by the introduction of automatic control are:—

1. In the wages bill.

2. The economy of gas arising through the more rapid lighting and extinction of lanterns.

3. Smaller number of breakages in mantles and chimneys.

4. Saving in expenses for various appliances which the lamplighters formerly required.

The saving in wages is considerable, and has been found to amount to at least 12 m. per lantern per annum. In gas consumption, as previously stated, a distinct economy has been made, and the general experience is that many breakages of mantles and chimneys, which used formerly to occur in the case of hand-lighting and extinguishing, are now avoided. In the 1,600 lanterns now installed, the total annual saving is reckoned at 14,400 m.

In the case of small towns, where there are, perhaps, only 50 to 250 lanterns to be lighted, the night-watchman often includes attention to these among his multiplicity of duties. There is, therefore, not the same opportunity for saving wages. On the other hand, the maintenance in these cases is often very unsatisfactory, and automatic control would often lead to an improvement in this respect.

In the discusson a lengthy contribution was made by Herr Director Kobbert, of Königsberg, who discussed the merits of electric, pneumatic, clockwork, and di-pressure wave appliances.

Electric and pneumatic ignition can be dismissed as not yet sufficiently reliable for public lighting, although they have been found serviceable for private purposes. Clockwork devices have, however, more practical advantages, and experiments were made with them in Königsberg for ten years. The chief defects are sensitiveness to changes in temperature and the fact that the time of action is settled separately by the mechanism inside each lantern, and independently of climatic conditions. It is thus impossible to hasten the time of lighting up should a mist come on, and reliance must be placed on a theoretical lighting schedule. The cost is also 30 per cent higher than wave devices. They are, however, entirely independent of the conditions of pressure in the mains.

Turning to pressure wave methods, Herr Kobbert laid stress on the importance of studying the conditions in the network of mains and adjusting the sensitiveness of the mechanism accordingly. The variation in pressure during twenty-four hours may be very large, and in the case of some very irregular networks, it might even be preferable on this account to use clockwork devices. The temporary increase in pressure for turning on and off lamps should be kept within the narrowest possible dimensions. A slight noise and a momentary increase in the light should be the only indication of the process received by the private consumer. Even this can be avoided by adding a governor to the premises. The impulse lasts about two to three minutes, but the time can be shortened by allowing a higher rise in pressure.

Some other points of interest were raised in the discussion. Herr Baurat Reese, for example, mentioned that statistics had shown that the percentage of accidents amongst attendants of street lamps, who spent their days mounting ladders, &c., was unduly large, and it was hoped that the automatic lighting would help to reduce the number of these mishaps. An improvement mentioned by Herr Metzger—providing more substantial footing on the ladders—was also spoken of with approval.

Herr Göhrum confirmed this suggestion about accidents, and added that automatic methods enabled a much better class of labour to be secured. In Stuttgart the percentage of defective appliances had been reduced to within 0·5 per cent, and a saving of 70,000–80,000 m. per annum had been made.

One other matter discussed was the difficulty of finding occupations for the lamplighters after the automatic system had been installed. Herr Metzger, however, explained that the best of them were selected to work under the new regime, and it was found possible to train the remainder to other jobs at the gas works.

The Electrical Exhibition at Olympia.

By an Engineering Correspondent.

The Electrical Exhibition, which was opened at Olympia by Sir Wm. Preece on Sept. 23rd, has been the subject of much comment in the electrical press, and it is unnecessary for us to do more than give a general account of the display.

While there were not on view many very novel items as regards methods of illumination, the display was a comprehensive one, and served to show the steady progress made in electric lighting. Taken as a whole, the Exhibition (like the recent Coronation decorations) showed a tendency towards more rational methods of spectacular lighting. There was less that was glaring in the illumination of the stalls, and more that was artistic and ingenious, than has been seen in some previous exhibitions, one feature being the more general use of frosted lamps and bead devices in the luminous signs in preference to bare lamps. It was also satisfactory to note that in the actual illumination of the exhibits the unscreened lamp, although still too prevalent, was less in evidence than on some former occasions.

Special Effects, Luminous Signs, &c.

On some of the stalls special devices to attract attention were employed.

Above the B.T.H. stall was hoisted a prominent model of the Earth, illuminated by Mazda lamps, the suggestion being that the functions of the sun had by this means been rendered superfluous.

A large model of the Earth also figured in the Sunbeam exhibit, illuminated by the motto "We light the world."

The General Electric Co. made use of a waving flag to which a series of Osram lamps were attached, and which gave proof of their strength by enduring a constant oscillation without suffering any apparent damage. Another attractive device on the stalls of the same company consisted in an illuminated transparency showing the lighting of the Tea Gardens at the Midland Grand Hotel, Manchester.

The Sun Electric Co. attracted notice by a luminous sun composed of yellow lamps with an orange corona, the rings of lamps being lighted up in succession radially.

The design of the stand of the Jandus Arclamp Co. was also distinctly novel, beaten copperwork decoration being employed. Two gilded recesses on either side of the stand were occupied by Jandus arclamps, a sheet of red glass being placed in front of one case in order to enable the structure of the long flame arc to be seen.

Illuminated signs were naturally in evidence. Large designs referring to the Ediswan and Pope lamps were outlined in frosted lamps. The stall of Messrs. Chamberlain and Hookham, Ltd., made liberal use of the Credenda and Venner signs, the feature of which is the use of illuminated glass beads on a dark background; and the employment of red or green lamps to illuminate these devices made the effect more striking.

Bead signs were also utilized by the Globe Electric Co., The Armorduct Co., and the Western Electric Co., Ltd. In the last two cases an effective display was obtained by restricting the colour of the decorations to red and blue respectively, bead letters down the sides and electric torches at each corner of the stand being employed.

There were also a number of stalls dealing exclusively with luminous signs and similar devices. The "Attracta" signs were shown by Messrs. Boddy

& Co., and some very curious changing colour devices by Sir J. Causton & Sons, Ltd. The Imperial Lighting Co. displayed a projection apparatus for illuminating flowing water with changing colours; and O. C. Hawkes, Ltd., displayed a form of gilt letter sign, serviceable both by day and night.

The Model Electric Home was once more a feature, the arrangements in this case being due to John Barker & Co. A complete suite of electrically lighted rooms was to be seen, and there was even a small garden studded with coloured lamps. The lighting of the various rooms was largely of the inverted type, and the liberal use of silk shades made the general effect very

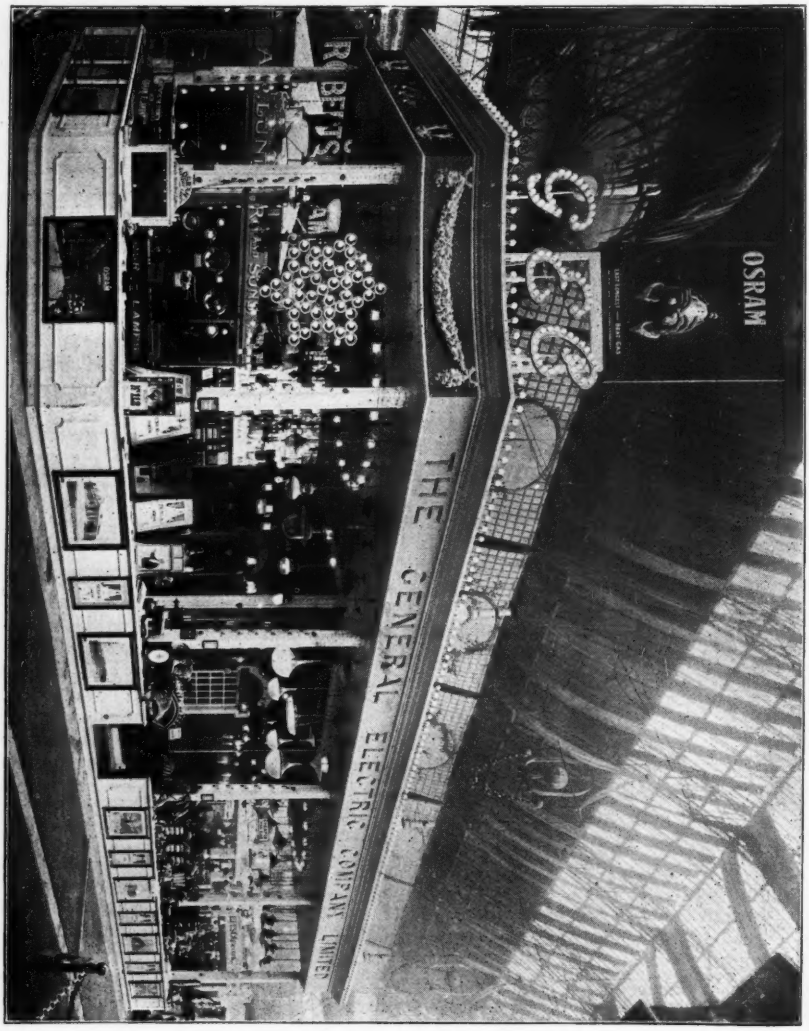

FIG. 1.—Exhibit of the General Electric Co., Ltd., showing Tungsten Lamps, Glassware, &c.

subdued; this style of lighting seems, for some reason, to be the variety usually adopted in "electric homes."

There remains to be mentioned the artificial garden of the London Electricity Supply Companies of London, which was a prominent feature near the entrance to the hall in which the exhibition was held.

Incandescent Lamps.

Incandescent lamps naturally formed the chief item in the lighting exhibits. At the General Electric Co.'s stall attention was drawn to the new 200 volt 16 c.-p. tungsten type. Ordinary and wire drawn Mazda lamps were a feature of the British Thomson-Houston Co., and the "Gem" metallized filament lamps, recently noticed in these columns, were also on exhibition. Messrs. Siemens Bros. had also an attractive display of carbon, tantalum, and one-watt lamp, including various small types for motor-car lighting, &c.

A variety of whirling arrangements causing these lamps to go through the most complicated evolutions without breakage were also in continuous motion.

The Brimsdown lamps, particularly the high candle-power types, made an attractive display, and the Ediswan, Pope, Sunbeam "Metallite," and other types were well represented. The Sun Electrical Co., in addition to the ordinary types, showed a new form of focus lamp with the filaments in one plane. Special reference should be made to the window, effectively lighted by concealed lamps, showing the various stages of manufacture of Pope lamps.

Arclamps and Vapour Lamps.

Arclamps were, as usual, well represented at the stall of the Union Electric Co. Ltd., a group of various types of Excello flame arcs, Kohinoor long burning arcs, &c. being shown. The Kohinoor "Triplex" lamp in particular merits attention; three of these are stated to be run in series on 220–250 volts. There was also a searchlight mounted aloft which swept the hall at intervals during the evening. Another interesting exhibit was a motor running merrily, without any apparent injury, under a constant stream of dripping water.

The Jandus enclosed flame arclamps exhibit has been already alluded to. The present type is stated to burn for 70 to 100 hours without attention and to give 4,000 c.-p. with a current of only 3 amperes.

A new form of enclosed flame arc with vertical carbons was also shown by the Abbey Electric Co. This is stated to give 6 c.-p. per watt and to burn for 30 to 40 hours with one pair of carbons. Another new enclosed flame arc was that on view at the stall of the Westminster Engineering Co.

There were also a number of other well-known arclamps on view. The Butt and Angold lamps were on show at the stall of the General Electric Co., an additional feature being types of arcs for photographic and cinematographic purposes. Messrs. Johnson & Phillips showed the Metroflam flame arclamp, which is stated to burn for 80 hours without recarboning, and the "Orb" enclosed lamp. The Foster Engineering Co. also exhibited arclamps and the small transformers of this firm were also a conspicuous feature. Yet another flame arc, the Multax, was on view at the stall of the Globe Electrical Co.

As regards mercury vapour lamps there were to be seen, in addition to the well known Westinghouse Cooper Hewitt types, the "Silica" lamp of the same company and the "Quartzlite" lamp of the Brush Electrical Engineering Co., both of which have received attention previously in *The Illuminating Engineer*.*

The most interesting novelty, however, was the Westinghouse Cooper Hewitt mercury tube lamp, fitted with the new Rhodamine pink reflector; by the aid of this reflector the usual green tint of the mercury arc was shown to have been considerably modified, the lips of people no longer appearing purple, but more nearly their natural colour.

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* *Illum. Eng.*, Lond., vol. iii., 1910, pp. 634, 635.

GLOBES, SHADES, AND REFLECTORS.

The stall of Holophane, Ltd. was naturally one of the most important in this section. A considerable variety of globes and reflectors was arranged round the exterior of the stall while, in a room within, a striking demonstration of the improved illuminaton secured by using a Holophane reflector instead of a bare lamp, was made. There were also a number of photographs of Holophane installations taken by artificial light, which were much admired by visitors. It may be added that, in addition to the exhibits on this stall, Holophane reflectors were very generally used throughout the Exhibition, and formed a prominent feature on the stalls of Messrs. Siemens Bros., the British Thomson-Houston Co., Messrs. Simplex Conduits, Ltd., the Benjamin Electric, Ltd., and others.

Messrs. Siemens Bros. showed a great variety of shades and reflectors which included a display of Holophane glassware, combined with tantalum lamps, and some tasteful forms of fixtures. The British Thomson-Houston Co., besides the Mazda-Holophane combination units, had an interesting selection of the new Mazda-lux metal reflectors, which have a matt interior reflecting finish. A series of these reflectors, containing Mazda lamps, were let into the ceiling of the stall forming an effective method of illumination.

FIG. 2.—Exhibit of the Union Electric Co., Ltd., showing various forms of Excello, Kohinoor, and other lamps.

Benjamin Electric, Ltd., displayed their "wireless" clusters, and special opal and Holophane reflectors.

On the Simplex stall the series of green and black spookie shades mounted round the roof was quite a feature, and the various table lamps of this type were also attractive. Another unit of interest was the tungsten street-lighting lantern, the inside reflector of which is made of spun aluminium.

Street-lighting incandescent units of 600 and 1,000 c.-p. were also to be seen at Mr. Haydn Harrison's exhibit. Combined with these was an interesting novelty, namely a local switch in the base of the lamp-post, which is intended to extinguish half the lamps at a given time in the evening. This device could be operated from the central station (in a somewhat similar way to the use of a pressure-wave in gas supply) by merely opening the main switch for an instant.

FIG. 3.—Simplex Tungsten Street Lighting Unit: contains one to eight 50 c.-p. lamps, and uses internal reflector of spun aluminium.

Forms of street-lighting reflectors using tungsten lamps were likewise to be seen at the stall of the General Electric Co. and mention should also be made of the "Whitehall" type of the Armorduct Co., using five 100 c.-p. "Gral" lamps.

There were also, in addition to those named above, a number of firms which showed electric fittings, many of them of a very decorative and elaborate kind. Messrs. Galsworthy, Ltd. included in their selection some interesting chandeliers and brackets in the Dutch style. The Sun Electrical Co. displayed the adjustable "Flexalite" candle-fitting, which can be bent over at any desired angle. Motor-car lights and projectors in great variety were exhibited at the "Bonella" stand. Other firms who had good displays were Messrs. Drake and Gorham, W. Jacobs, A. C. Hands, &c.

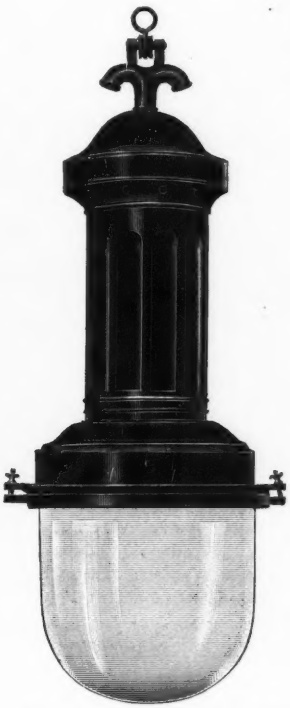


FIG. 4.—The Armoduct "Whitehall" Tungsten Street Lighting Unit.

PHOTOMETRY, MEASURING INSTRUMENTS, HEATING AND COOKING, &C.

There were also a variety of other electrical exhibits which do not fall strictly within the scope of this journal. Heating and cooking demonstrations attracted much attention while electrical engineers found much of interest in the stalls of the various well-known firms dealing with measuring apparatus. Among the latter were a few instruments for measuring light and illumination. Messrs. Alex. Wright & Co. displayed a standard form of photometric bench with a rotating lamp-holder, and also exhibited their form of street-photometer. Holophane, Ltd. had the "Holophane Lumeter" on exhibition while the Luxometer apparatus was to be found on the stall of Messrs. Everett, Edgcumbe & Co., Ltd.

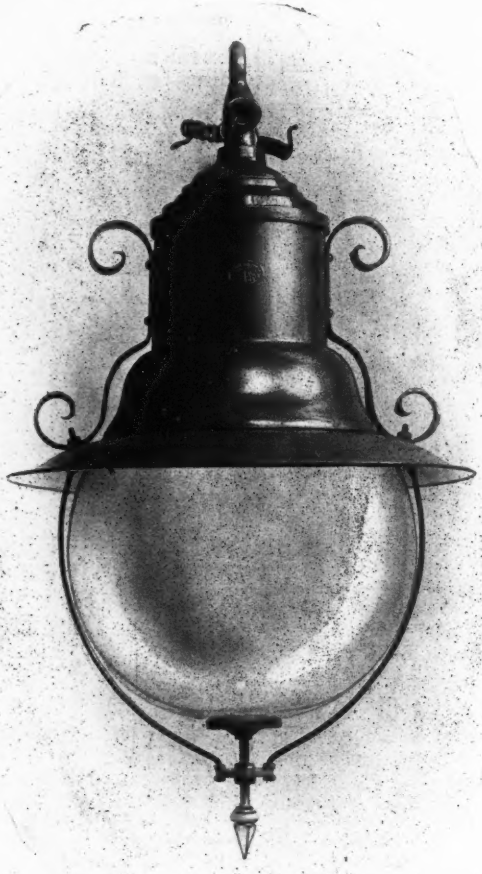


FIG. 5.—Haydn T. Harrison's Special Street Lighting Unit.

The Aster and G.E.C. petrol direct driven electric generating sets, of the variety frequently used for country

lighting, were perhaps the most interesting items among the electric machinery from the lighting standpoint, and the metal work and ornamental switches and panels of the London Decorative Metal Work Co. should also be mentioned.

Other interesting items were to be seen at the Edison stall where the "Dictograph" and the Edison accumulators for which such remarkable properties are claimed, were on view.

Some Suggestions.

While it is generally conceded that a very representative display was secured at this exhibition, which was supported by many of the leading electrical firms, there has naturally been some discussion in the electrical papers and among exhibitors as to how far it succeeded in attracting the general public.

In some quarters the attendance of the general "non-technical" public was considered disappointing, and this has been ascribed partly to the fact that the co-operation of the press had not been sufficiently sought beforehand so as to make the nature of the exhibition known. However this may be, it will be admitted that the average member of the general public finds it difficult to benefit from electrical exhibitions. He is bewildered by the multiplicity of lamps and the succession of stalls, and has, no means of weighing the statements and the frequently conflicting claims put forward. It has, therefore, been suggested that it would be better in future displays of this kind, to arrange the exhibition in sections, lamps and illuminating appliances being arranged in one quarter, dynamo electric machinery in another, measuring instruments in a third and so on. Bold illuminated signs of different colours might be used to indicate the respective sections. The visitor would thus be free to concentrate attention on the sections that interested him without being distracted by the task of picking out the particular exhibits he wished to see from this confused mass.

This method would doubtless demand some concessions and co-operation on the part of exhibitors, but efforts in this direction would be well repaid. This co-operation might also be extended so as to include joint exhibitions on points of special interest—for example, a stall showing the progress of illuminants from the most ancient and primitive devices up to the highly efficient lamps of to-day (as has been done at certain German exhibitions) would deservedly attract attention. Again, much more might be done by arranging for popular and attractive lectures on lighting and heating, not intended to benefit any particular apparatus, but designed to show progress in lighting or heating as a whole.

Fig. 6.—"Flexalite" Fitting.
(The Sun Electrical Co., Ltd.)

Above all, something further might surely be arranged in the way of novel demonstrations of the *use* of lamps—for example, the very latest and most up-to-date methods of lighting shop windows, pictures, drawing rooms and various kinds of interiors, the historical development of street lighting, etc.,

FIG. 7.—Exhibit of Messrs. Siemens Bros. Dynamo Works, Ltd., showing display of Tantalum and Onewatt lamps, Holophane reflectors, &c.

FIG. 8.—Exhibit of the Globe Electric Co., Ltd.; the stall is surrounded by Multax Flame Arcs.

which should be treated by experts on these subjects. Such demonstrations would surely prove more effectual in attracting interest from the general public than the present method of arranging groups of lighted lamps on stalls, most of which look very much alike to the uninitiated. They would also provide the Daily Press with more interesting material for journalistic purposes.

HOLOPHANE LIMITED.
12, CARTERET ST. QUEEN ANNES GATE, S.W.
HOLOPHANE
SCIENTIFIC SYSTEM OF
LIGHT ON THE OBJECT NOT IN THE EYE
LIGHT ON THE OBJECT NOT IN THE EYE

FIG. 9.—Stall of Holophane, Ltd., showing representative collection of Holophane Glass Globes and Reflectors.

[In addition to the above article we have received, from a second correspondent, an account of his impressions of the Exhibition. We reproduce this in the following contribution, and would draw the attention of readers to the general agreement between the views expressed in the two articles, as regards the methods of illumination employed.—ED.]

Some Impressions of the Methods of Illumination at the Electrical Exhibition of 1911.

By an Engineering Correspondent.

In commencing this article the author would like to make it clear that his comments on the Exhibition are intended to apply solely to the methods of illumination employed, and not to the nature of the exhibits.

The success of the lighting section of an exhibition of this kind depends on two distinct factors — the interest of the exhibits themselves, and the skill with which they are illuminated, so that their value and uses may be made apparent to the visitors. The trouble is that in many cases these two matters appear to have been confused ; in their anxiety to display the actual lamps and shades many exhibitors have prejudiced the value as a demonstration of their successful use.

Let us commence by referring to the illumination of the main entrance to the Exhibition.

This was illuminated by Excello arc lamps, and there was also a moving electric sign. The arc lamps, however, failed to achieve their purpose, owing to their having been placed at least 6 ft. too low down, and the sign was also of a size unsuitable for the purpose. There were also two searchlights, the object of which was by no means clear, as the beams from them invariably passed into the air, and were rarely directed so as to illuminate any particular object. As a means of suggesting to visitors the wonderful possibilities of electric lighting the arrangements in this direction were singularly unsatisfactory, and it may be hoped that on a future occasion something more striking and original will be contrived.

On entering the exhibition one was again struck by the lack of originality in light-effects and the many instances in which lamps and reflectors seem to have been incorrectly used.

One of the very first exhibits encountered was that of the British Post Office. One would surely expect that in this case some attention would be paid to the illumination of the exhibit, and that the working conditions, as regards illumination, would be made as convenient for the telephone operators as possible. Yet from the standpoint of the illuminating engineer the exhibit was, to say the least of it, capable of considerable improvement. Near by was to be noted an exhibit of heating and cooking apparatus in which the illumination was again faulty, much of the light being projected into the observers' eyes.

Moving onwards one met many other instances in which a little care would have led to vastly improved results. A common defect was the metallic filament being too long for the shade employed, so that the bulb projected and allowed the filament to be seen ; the effect was thus distinctly glaring and the shade was not turned to its proper use. Again, in spite of the multitude of lamps, one sometimes found that the desk or table at the stall was insufficiently illuminated and could not be used with comfort. In other cases the effect of the shades (of a good type in themselves) was nullified by the lamps being arranged with their axes at 45 to the horizontal, with the result that, whatever direction one looked at the stand, one's eyes encountered these bright surfaces. Some exhibits were spoiled by unshaded clear bulb lamps being exclusively employed, and the one case in which an incandescent lamp company utilized half frosted lamps throughout their exhibit justified itself by the comparatively artistic appearance of the stand.

As an illustration of the prejudicial effect of glare from unscreened filaments,

the writer recalls one particularly neat and well-arranged reception room where the multiplication of lamps round the room quite took away all sense of comfort. One large exhibitor adopted an ingenious method of mounting the apparatus to be shown on white marble and illuminating its surface with concealed lights ; unfortunately, clear glass bulbs were used, with the result that the image of the filament was very noticeable by direct reflection from the marble surfaces. Either the marble slabs should have been mat or obscured lamps should have been used.

In the case of arc lamps one has again to draw a distinction between the exhibition of the working of the lamps themselves and of their use for purposes of illumination. The usual defect was that powerful lamps were hung round the stall only slightly above the visitor's head ; their brilliancy consequently made it very difficult for him to see anything of the exhibit, and also "killed" surrounding exhibits. One well-known firm, however, adopted a better plan in placing the lamps actually alight at the top of high masts, preferring to use unlighted models near the floor in order to show the mechanism, etc.

As regards shades and reflectors and fixtures, it may be repeated that in many cases the qualities of really effective appliances were obscured by their improper use. For example, the wrong shape of lamp for a reflector was often used, with the result that the bulb poked out and showed the filament, and the natural distribution of light was rendered incorrect.

The crowding together of so many of these shades, globes, and reflectors made it hard to judge what their illuminating effect in practice would be, while the juxtaposition of powerful unscreened lamps often made it still more difficult to estimate their possibilities. Seeing that the whole object of most of these reflectors is to screen the light from the eyes and direct it usefully downwards, one would have supposed that the aim of exhibitors would be to emphasize these qualities. In spite of this the reflectors were sometimes arranged in such a way that the light streamed straight outwards into the eyes of passers-by ; the very quality of concentrating the light which is designed to *avoid* glare was actually used to *produce* it. The writer has in mind one well-known firm which deals in this speciality and erred badly in this respect. On approaching their stand one was confronted by two rows of lamps and shades placed on vertical pillars on the right and left hand sides of the entrance ; although mercifully obscured as regards the lamps and some of the shades, this arrangement nevertheless cast the light directly into the eyes of those approaching the stand, and formed an uncomfortable feature in an otherwise excellent display. Such exhibits are surely hardly in keeping with the motto, "Light on the object, not in the eye."

The exhibition furnished a number of instances in which special methods of illumination were employed with fair success. Noticeable in this direction were the various bead signs, illuminated by coloured lamps, of which extensive use was made. In some instances concealed lights were used with effect for the illumination of show cases, and it is surprising that the method is not more generally adopted. There were also attempts to illuminate posters and pictures by concealed lights—one of the best examples being that in one of the rooms of the model electric home. It was rather curious to note that whereas a subdued, not to say funereal effect was aimed at in the drawing-rooms, &c., in this home, there was an immediate reversion to unscreened filaments in the kitchen and laundry. The chief defect was the inequality of illumination, the portions near the lamp being almost invariably considerably brighter than the more distant portions. Illuminated transparencies were also successfully employed, but in some instances a very spotty effect was produced by the employment of clear bulb unshaded lamps.

A word may be said about the combined exhibit of the London Electric Supply Companies, the Italian Garden. As an architectural object the stand was not without merit, and it is to be regretted that it did not form an

isolated block. As a demonstration of electric lighting illumination there were many defects. The hanging lights were directly in the line of sight (and that this was so seemed to be recognized in the more recent addition of bamboo blinds, which were let down in front of lamps while people were attending the lectures). The special illumination of the Italian scenery painted on the end walls is carried out by metal filament lamps in tin boxes, this being apparently the limit of the conception of special illumination on the part of the designer. The illumination of these walls was also interfered with by the light from neighbouring arc lamps. The various maps in the gardens were lighted by fittings which probably gave twenty times as much light on the top of the maps as at the bottom, and the rotary screen carrying advertisements was also far from uniformly illuminated.

The chief conclusion that seems to be suggested by this visit is the immense scope for educational work on the part of the Illuminating Engineering Society in calling the attention of electrical contractors and supply houses to the advantages of arranging their illuminating apparatus in a proper manner; also in inducing electrical supply companies and their assistants to impress upon the consumer the desirability of having the best possible advice on illumination. An examination of the list of the Executive Committee of the Exhibition shows that the Illuminating Engineering Society is not represented. Possibly this may account for the absence of crystallized ideas as to the best methods of general lighting of the exhibition and the local lighting of the various stands. It may be hoped that the next exhibition will reveal better appreciation of the characteristics of good illumination.

Illuminating Engineering Society.

(Founded in London, 1909.)

Official Notice of Next Meeting.

THE next meeting of the Illuminating Engineering Society will be held at the house of the Royal Society of Arts (John Street, Adelphi, London, W.), at 8 P.M. on Friday, November 17th, when the HON. SECRETARY will present a BRIEF REPORT on PROGRESS DURING THE VACATION, and a paper will subsequently be read by DR. H. R. B. HICKMAN, M.A., M.B., M.R.C.S., L.R.C.P., entitled **Notes on the Design of Motor Car Headlights.**

Members desiring to join in the discussion are invited to send in their names to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.) beforehand.

We are informed that the telephone number of Prof. SILVANUS P. THOMPSON, of "Morland," 18, Chislett Road, Hampstead, N.W., is now 4668 P.O. Hampstead.

Royal Sanitary Institute Congress in 1912.

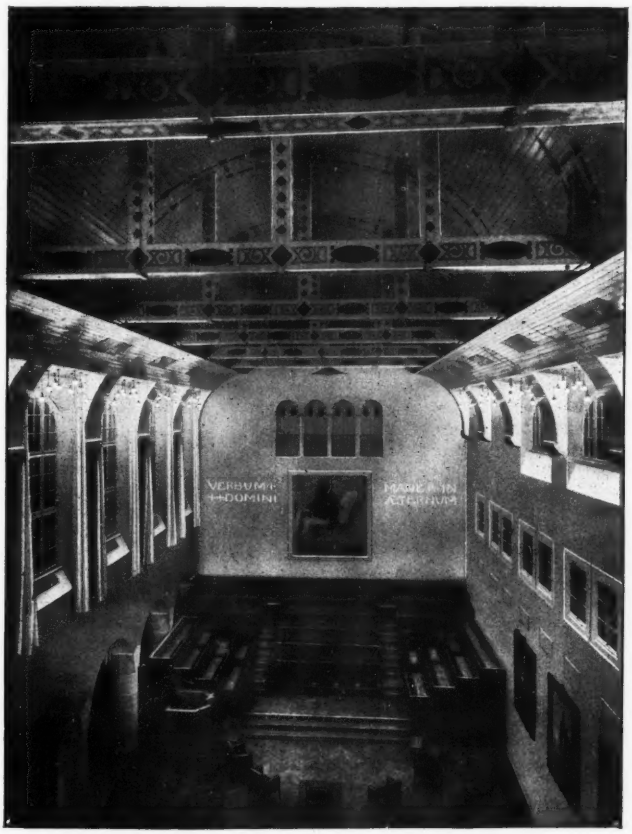
WE are informed that the Royal Sanitary Institute have accepted an invitation from the City Council of York to hold their 27th Congress and Exhibition in that City from July 29th to August 3rd, 1912.

Short Notes on Illuminating Engineering.

From all Sources.

An Example of School Lighting in Germany.

THE illustration shows the method of lighting adopted in a hall used on special occasions in one of the schools in Germany. Attention may be drawn to the method of hanging the lights high up the sides of the room out of the range of view. For this illustration we are indebted to the courtesy of the Siemens Schückert Co. of Berlin.



Drawn-Wire Lamps in a Modern Theatre Installation.

THERE are several features of interest in the lighting installation at the Prince of Wales Theatre, Birmingham, which has recently been reconstructed. Special attention has been paid to artistic effect in the lighting scheme, the foyer and main staircase leading to the grand saloon being furnished with handsome three-light electroliers and side brackets, finished in dull gold. A very brilliant ceiling light is provided in the form of an imposing electrolier containing some fifty lamps, but, largely owing to the use of frosted bulbs, we understand that no unpleasant glare is experienced. Drawn-wire Mazda lamps have been used throughout the installation, and their use for the footlights and batten lights on the stage is somewhat of a novelty. Until the introduction of the drawn-wire lamp, it was not considered advisable to use metal filament lamps on the stage, owing to the vibration and rough usage that they might be subjected to; there was also a difficulty in using the old type of dimmer on circuits of metal filament lamps. The strength of the drawn-wire filament obviates the first difficulty, and the second objection has been met by the introduction of a specially designed dimmer. The installation is of considerable size, the theatre lighting alone, apart from the stage, using as many as 1,500 lamps. The work was carried out by the British Thomson-Houston Co., to whom we are indebted for the above particulars.

Protecting the Eyes of School Children.

IN America a good deal of attention is being paid at the present time to the question of eyesight of school children and the effect on the eyes of lighting conditions in schools. Some suggestions have recently been presented to the Board of Education as the outcome of a conference between the Association of Women Principals of the Public Schools in New York City and some eminent oculists. Several of these remarks are directed against bad conditions in reading classes. For example, it is recommended that shiny paper should not be used in school books; that half-tone pictures should be replaced by simple outline pictures; and that there should be not less than 3 mm. between the lines of type.

It is also suggested that rooms in which artificial light is used continually should be prohibited; that electric lamps in class-rooms should be of frosted glass, and that clusters of such lamps should be provided with pale amber shades to screen the pupils' eyes from the direct rays of light.

Public Lighting and the Popular Vote.

A CURIOUS situation has recently arisen in the town of Ashford, in Middlesex, a decision having been taken to abstain from the public lighting of its streets. To remain in darkness is not, however, the wish of the majority of the inhabitants. It appears that the Parish Council were unanimously in favour of a scheme of public lighting by gas; but at a meeting of the parish at which the matter was considered, there were nine dissentients, and a poll was demanded. According to the regulations, at least 617 persons must vote, and two-thirds of this number must be in favour, in order that the resolution may be carried. At the poll, which took place on October 7th, in spite of the strenuous efforts that were made by some, the requisite number of votes was not secured, and therefore the town remains in darkness. It is significant that while 326 voted in favour, only 25 were against, but the incident shows that there are still people who are curiously unresponsive even to most elementary demands for lighting.

Inverted Burners in South London Streets.

WE understand that in a large number of streets in South London the lamps have recently been converted from the upright burner to the inverted type. This has resulted in a considerable improvement in the downward distribution of the light. The new burners are considered to have a decidedly better appearance than the former, and are doubtless more efficient.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination

The contents of these pages in which is included information supplied by the makers, will, it is hoped, erve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information elating thereto.]

An Interesting High-Pressure Gas Installation.

WE learn that the city of Altona has decided to use Pharos high-pressure gas lamps on a large scale in the public streets, an order for sixty such lamps having been already placed with the Deutsche Gasglühlicht A.G.

The plant is to be installed by the end of November, and the lamps are to be placed on street suspensions in such a way as to be capable of being raised and lowered from the centre of the street to the sidewalk without the high-pressure gas supply being interrupted.

Another interesting feature will be the new extinguishing apparatus with which these lamps are to be furnished. Lamps with two burners will be used, and either one or two of the burners can be lighted up automatically from a distance by means of a pressure wave from the gas works; thus at a time in the evening when it is no longer necessary to have the full light, a sufficient illumination is provided from the use of one burner only, with a corresponding reduction in the gas consumption.

Wireless Cluster Fittings and Shop Window Reflectors

Messrs. The Benjamin Electric, Ltd. (117, Victoria Street, London, S.W.), have sent us a neat little booklet, in which are set forth the special features of the WIRELESS CLUSTER FITTINGS which they are introducing. In these clusters the lampholders are all connected up in a mechanical way, so that in erecting a fitting there is no wiring to do beyond that required to connect the main terminals of each cluster. This will ensure freedom from risk of short-circuits and a simplicity of fixing which cannot be obtained when a cluster is built up with a brass ball and ordinary lampholders. A large variety of these fittings are listed, and we understand that they can be supplied connected either in parallel, series, or divided circuit. The booklet also gives examples of Benjamin clusters

fitted with opal shades, Holophane reflectors, and various types of decorative shade.

The Benjamin Electric have also issued a list describing some of their SHOP WINDOW AND SHOW CASE SPECIALITIES. Among these may be mentioned the adjustable reflector illustrated above, and the curved section reflector, which has been designed for use above the window

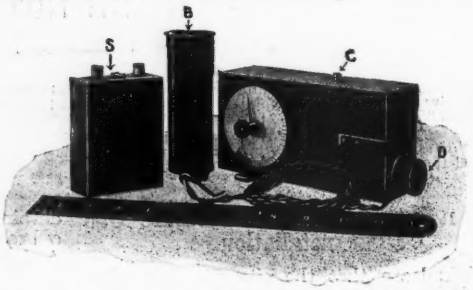
in order to concentrate the light on the goods to be displayed. A small length of this type of reflector may be adapted to the lighting of show cases, and we illustrate one type which has been brought out fitted with feet and suitable for standing on the top of a glass case.

Messrs. G. M. Boddy & Co. inform us that their new address is 8, Leadenhall Street, E.C. They also ask us to mention that since the recent patent litigation they have adopted the "MAZDA" DRAWN-WIRE LAMPS, which they are now supplying to their customers.

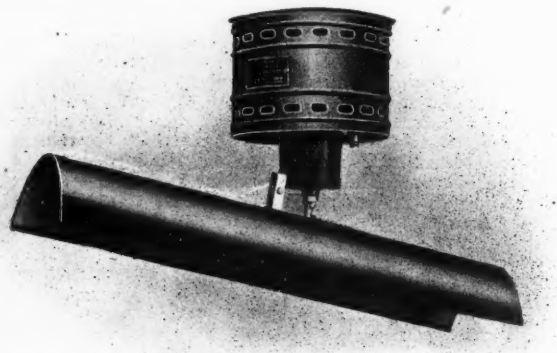
The Luxometer.

We have received from **Messrs. Everett, Edgcumbe & Co., Ltd.** (117, Victoria Street, Westminster, S.W.), some particulars of the small portable illumination photometer which they manufacture under the above name.

The appearance of the instrument, with its pocket battery and daylight attachment, is shown in the accompanying illustration. It is very compact and light, weighing only 1½ lb., and has a direct reading scale. The length of the scale is about 6 in., and it is graduated up to 10 or 20 foot-candles, as preferred, being fitted with two ranges in either case. By means of the daylight attachment referred to above, measurement can also be made of the "window efficiency" of a room—*i.e.*, the ratio between the illumination inside the room and that produced by uninterrupted daylight outside. A yellow tinted external screen is provided in order to simplify the taking of daylight readings. As the same screen is also used for the indoor measurement, no allowance need be made. When in use the photometer is



held in the hand, no stand or other support being required. For transport, both the photometer and the battery can be carried in the pocket, or they can also be supplied in a small leather case.



A New Reflector for Mercury Vapour Lamps.

The above illustration shows the new rhodamine reflector, brought out by **The Westinghouse Cooper Hewitt Co.** (151-2, Gt. Saffron Hill, London, E.C.), and described in detail on p. 628. This reflector, which is of fluorescent material, supplies the red rays in which the ordinary mercury vapour lamp is deficient, and thus greatly improves the colour value of the lamp, giving a closer approximation to white light.

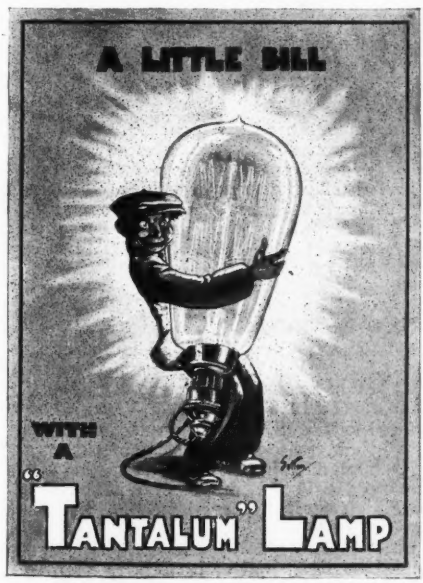
Extended Popularity of Gas Fires.

We have received a note from the **Gas Light and Coke Co.** (Horseferry Road, Westminster, S.W.), in which they draw attention to the growth in popularity of gas fires in recent years. This has been due, they suggest, to the improved design, accompanied by the increased efficiency of the fires brought out during the past two or three seasons. The modern stove, we are told, costs less than a penny an hour to burn and can be hired at a rental of about a penny a week.

"Mazda" Lamps.

Messrs. The British Thomson-Houston Co., Ltd. (83, Cannon Street, London, E.C.), have recently issued a modification of their well-known "Mazda" lamp poster, in which the special feature—mechanical strength—of the new drawn-wire lamps is emphasized. The black-and-white reproduction herewith gives some idea of the chief features of the design. The same firm have also issued an attractive booklet, in which they trace the development of the metallic filament lamp, pointing out how its introduction has enormously reduced the cost of *electric light*, even though the cost of *electricity* has remained the same. The text is written in popular style and illustrated throughout with small line sketches.

The British Thomson-Houston Co. also inform us that their lamp and wiring supplies department has, on account of the large increase in business, been transferred to Mazda House, 77, Upper Thames Street, E.C.



The "Little Bill" Showcard.

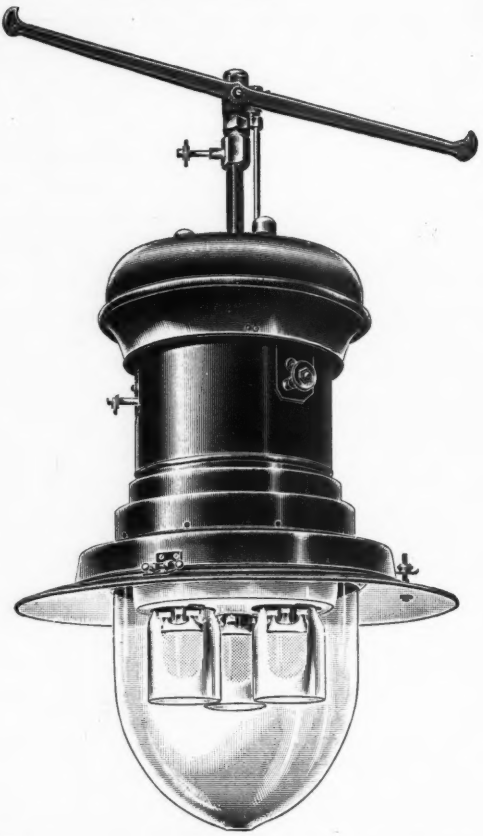
The accompanying illustration shows a NEW SHOWCARD, which was one of the successful designs in the competition organized by **Messrs. Siemens Bros. Dynamo Works,** and referred to in our last number. It will be known as the "Little Bill" showcard, and is already much in evidence.

A 16 Candle-Power Metal Filament Lamp for Voltages up to 260.

A new low candle-power high-voltage metal filament lamp has recently been placed on the market by **Messrs. The British Thomson-Houston Co.**; and **Messrs. The General Electric Co., Ltd**, have also introduced a 16 candle-power lamp with small bulb for use on circuits up to 260 volts. We understand that **Messrs. Ediswan** are introducing a 24-watt lamp for the same voltage, and a 12-watt lamp for voltages up to 130.

"Nico" High Candle-Power Low-Pressure Lamp.

The lamp we illustrate herewith has been designed with a view to the requirements of shop lighting and general out-door work. Its efficiency is stated to be as much as 40 candles per cubic foot of gas, and this is obtained with the pressure of the ordinary supply. The lantern is arranged to take two, three, or four burners, each burner being designed to give 250 candle-power. In addition to gas and air regulators, the lamp is fitted with a dust ejector, which frees the gas-way from obstruction by forcing a needle plunger through it. The lamp is manufactured by the **New Inverted Incandescent Gas Lamp Co., Ltd.** (19 and 23, Farringdon Avenue, London, E.C.).



Reduction in Price of Metal Filament Lamps.

We have received notice of REDUCTION IN PRICE OF LAMPS from the following firms:—**Messrs. British Thomson-Houston Co., Messrs. Ediswan, Messrs. General Electric Co., Messrs. Falk, Stadelmann & Co., and Messrs. Siemens Bros. Dynamo Works, Ltd.** The following alterations have been made:—

Lamps from 100 to 135 volts, and up to 55 watts .. .. .. 2/6 each.
Lamps from 200 to 260 volts, and up to 55 watts .. .. .. 3/- each.

Catalogues Received.

Haydn Harrison (11, Victoria Street, London, S.W.) sends us a fully illustrated catalogue of STREET LIGHTING FITTINGS, APPARATUS, AND ACCESSORIES. This, we understand, is a second edition, embodying many improved designs introduced since the edition of 1909. At the conclusion of the catalogue we notice some pages devoted to the question of light distribution from the high candle-power lamps mentioned in the foregoing pages, and typical polar curves are reproduced. A short description of the Harrison Street Photometer and some useful street lighting data are also included.

The Metallic Seamless Tube Co., Ltd. (Wiggin Street, Birmingham), send us a list of their latest designs of pendant and other DECORATIVE FITTINGS.

The Linolite Co. (25, Victoria Street, London, S.W.) have sent us a copy of their price-list, together with a short pamphlet emphasizing the special features of the TUBOLITE system of illumination.

Messrs. Mather Bros. (36, Farringdon Street, London, E.C.) send us a list of "Efesca" and "Invicta" AUTO-TRANSFORMERS, and call attention to a reduction in price.

CORRESPONDENCE.

Estimating the Tone of Mounts used in Photography.

DEAR SIR,—Mr. J. S. Dow and Mr. V. H. Mackinney have, in enumerating in their interesting article in your September issue on the 'Value of Photography in Illuminating Engineering' some of the many directions in which a photometer such as the Lumeter has proved of service to photographers, omitted to make reference to its utility in the multiple mounting of the finished photographic prints. In this system of mounting the prints are, as your readers who are also photographers will, of course, be aware, in effect surrounded by a series of frames of variously tinted mounting papers, each of which *should* have some definite relationship to the tone values in the print being treated.

Under ordinary circumstances it is sometimes a matter of considerable difficulty to correctly determine the most appropriate tone values for a given print, and a considerable amount of time is often expended in obtaining, by the trial and error method, a result which is frequently anything but as perfect as it might be. Most of this time can be saved and a more artistically correct result obtained by the use of the Lumeter for the purpose of, in the first place, standardizing the complete range of mounting papers used, and, in the second, accurately determining the tone values present in the print to be treated.

Both mounting papers and prints should always be examined by the same light and at the same distance from it, as, for instance, by a bromide or gaslight paper printing board, furnished with a metallic filament incandescent lamp. The light should be screened on the side opposite to the mounting paper or print, and the observer and Lumeter be stationed well behind it. Sheets of the various papers can be placed in position on the board and their surface-brightness very quickly determined by the photometer and recorded upon the packets containing them.

The tone values present in a photographic print can in like manner be ascertained and recorded *in a few moments*, and it is thus quite a simple matter to select a series of appropriate mounts either within the limiting values of the print, or exceeding or falling short of such, by any predetermined amount.

The method, although a little difficult to describe, is in practice as expeditious as the results obtained are satisfactory.

I am,

Yours, &c.,

THOMAS ED. RITCHIE.

New President of the Northampton Institute.

UNDER the newly constituted scheme of management of the Northampton Polytechnic Institute, the Governors have power to appoint a President, and we understand that H.R.H. the Duke of Connaught, K.G., has been offered and has graciously accepted the new office.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

THE most important source of information in the past month has been the series of papers read at the **Convention of the Illuminating Engineering Society (U.S.A.)**. This, however, is treated fully elsewhere in this number. The American *Illuminating Engineer*, besides referring to this convention, contains several articles analyzing the work of the American Illuminating Engineering Society, and giving tables showing the distribution of membership. Two suggestions are made —*firstly*, that the Society should endeavour to secure fuller co-operation from other kindred outside associations; and, *secondly*, that efforts should be made to provide better representation of non-engineering elements such as the architectural and medical professions. Among other American items, we may mention several interesting recent editorials in the *Electrical World*. In one of these reference is made to the researches of two investigators who confirm the work of Ives on **luminous efficiency** very closely; with the ideal green light as much as 55 c.-p. per watt is thought to be theoretically possible. Other remarks deal with **acuteness of vision** by light of different colours.

Among British contributions, two of the most interesting are those of MANKTELOW on **Workshop Lighting** (*Elec. Rev.*, Oct. 6), and the serial articles in the *Electrician* by R. A. HOUSTOUN on the **Theory of Light Production.** The former gives an excellent summary of recent information published on factory illumination; he comments upon the existing legislation, urging the need for more detailed recommendations and the measurement of illumination, day and artificial; he also gives a series of tables in which the data obtained by L. MARKS and others for the illumination in spinning factories, textile works, sewing machines, and other varieties of work, are set forth. The articles by R. A. HOUSTOUN are also in the nature of a summary, the radiation and luminous efficiency of the incandescent electric lamp and the mantle being dealt with.

ELECTRIC LIGHTING.

THE chief items in this department (excluding the Electrical Exhibition at Olympia, which is, of course, fully dealt with in the British electrical journals) are the data on the campaign in favour of **Improved Public Lighting** and some notes on **Electric Sign Lighting** in the *Electrical Review of New York* (Sept. 16). A number of types of ornamental street lighting posts are illustrated, and the keen interest taken in the matter by municipal authorities in the United States is commented upon. Stress is also laid on the extremely rapid growth of electric signs in Chicago (ten years ago there were only 20, there are now over 5,000), and various types of spectacular devices are shown. A point to be remembered is that flashing signs, besides attracting attention by the alterations in light, also economise current.

LOEWE (*E.T.Z.*, Oct. 5) discusses tariffs and advocates the pushing of 50 c.-p. lamps in preference to low candle-power ones. RUSSNER gives further tests of the luminous efficiency of carbon and metallic filament lamps (*E.T.Z.*, Oct. 12): these work out to only 1·5 per cent and 4·5 per cent respectively. SCHLESINGER continues to marshal arguments comparing the comparative hygiene of gas and electric lighting.

An interesting summary of **Attempts to Improve the Colour of Mercury Lamps** also occurs in the *Electrical Review of New York* (Oct. 14).

GAS LIGHTING.

A. ALBRECHT (*J.f.G.*, Oct. 7) gives a number of illustrations of **modern gas lighting installations,** one of the most interesting showing the use of inverted lighting in a modelling room. The paper gave rise to a particularly animated discussion.

A contributor to the *Zeitschrift für Beleuchtungswesen* (Sept. 30) sketches the very primitive methods of turning on and off gas by means of a hand-operated mercury plug in the early days of gas lighting (about 1812).

H. J. ROGERS (*J.G.L.*, Oct. 17) reviews a number of subjects of interest, including high-pressure lighting, street lighting specifications, the conditions of pressure on consumer's premises, the education of gasfitters, &c. Other numbers of the British journals describe high-pressure installations in Ilford, at the Scottish Exhibition, and elsewhere.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Editorials. The Investigation of Illumination (*Elec. World*, N.Y., Sept. 23).
Studies in Luminous Efficiency (*Elec. World*, N.Y., Sept. 30).
Direct and Indirect Lighting (*Elec. World*, N.Y., Oct. 7).
Visual Acuity by Coloured Lights (*Elec. World*, Oct. 14).
The Illuminating Engineering Society (*Illum. Eng.*, N.Y., October).
Erlwein. Ueber Wassersterilisierung mittels Ultravioletten Strahlen (*J.f.G.*, Sept. 30).
Houstoun, R. A. Studies in Light Production (*Electrician*, Sept. 29).
Manktelow, W. Workshop Lighting (*Elec. Rev.*, Oct. 6).
The Illuminating Engineering Society, U.S.A., Fifth Annual Convention (*Elec. World*, N.Y., Sept. 30, Oct. 7; *Elec. Rev.*, N.Y., Sept. 30, Oct. 7).
Marshall, A. J. Considering the Illuminating Engineering Society (*Illum. Eng.*, N.Y., October).
Schepmoes, L. Railway Car Illumination (*Illum. Eng.*, N.Y., October).
Das Aronsche Chromoskop (*Z.f.B.*, Sept. 30).
Int. Lichtmesskommission (*J.f.G.*, Oct. 14).
Indirect Illumination of a Large Domed Interior (*Elec. World*, N.Y., Oct. 7).
Illumination of the World's Largest Transmission Gear Factory (*Elec. Rev.*, N.Y., Sept. 16).

ELECTRIC LIGHTING.

Editorials. The Campaign in Favour of Improved Street Lighting (*Elec. Rev.*, N.Y., Sept. 16).
Special Applications of Incandescent Lighting (*Elec. Rev.*, N.Y., Oct. 7).
Gage, H. P. The Radiant Efficiency of Arc Lamps (*Phys. Rev.*, August).
Loewe, A. Popularisierung der Elektricitäts (*E.T.Z.*, Oct. 5).
Russner, A. Die Strahlungseigenschaften elektrischer Glühlampen (*E.T.Z.*, Oct. 12).
Schlesinger, K. Wie sind elektrische und Gasbeleuchtung hygienisch zu bewerten? (*E.T.Z.*, Sept. 28).
Processes for Modifying the Colour of Mercury Lamps (*Elec. Rev.*, N.Y., Oct. 14).
Electric Sign Lighting (*Elec. Rev.*, N.Y., Sept. 16).
The Campaign in Favour of Improved Street Lighting (*Elec. Rev.*, N.Y., Sept. 16).

GAS, OIL, AND ACETYLENE LIGHTING.

Albrect, A. Ausgewählte Beispiele aus dem Vordringen des Gases in Kleinstadt und Grosstadt (*J.f.G.*, Oct. 7).
Editorials. High Pressure Gas Schemes for Street Lighting (*J.G.L.*, Sept. 26).
Joint Standard Bill Promotion (*J.G.L.*, Oct. 10).
Candle and Calorific Power at High Pressures (*J.G.L*, Oct. 10).
Rogers, R. H. J. Fittings and Sales Dept. (*J.G.L.*, Oct. 17).
Report of the Société Technique du Gaz (*J.G.L.*, Sept. 26).
Sugg High C.-P. Low Pressure Lamp (*J.G.L.*, Sept. 29).
The Single Gas Unit for Commercial Lighting (*Prog. Age*, Oct. 2).
Front Lighting (*Prog. Age*, Oct. 2).
Competition in Illumination (*Prog. Age*, Oct. 16).
High Pressure Gas Lighting at Ilford (*G.W.*, Sept. 30).
Lighting of the Glasgow Exhibition (*J.G.L.*, Oct. 24).
Zur Theorie des Gasglühlichts (*J.f.G.*, Oct. 14).
The Dresden Hygienic Exhibition—Gas, Petroleum, and Spirit Lamps (*J.f.G.* Oct. 7).
Die erste Gasbeleuchtung in Berlin (*Z.f.B.*, Sept. 2, 30).
Neuerungen an Invertbrennern....Laternen für Hängelicht (*Z.f.B.*, Oct. 10, 20)
Automatic Ignition of Acetylene (*Acetylene Jour.*, Oct.).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*

G. W.—*Gas World.*

Illum. Eng., N.Y.—*Illuminating Engineer of New York.*

J. f. G.—*Journal für Gasbeleuchtung.*

J. G. L.—*Journal of Gaslighting.*

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

Some Publications Received.

Progress in Illumination and the Gas Industry during 1910. By Prof. Dr. H. Strache.

Technical Hints for Architects and Householders. By L. Bloch and R. Zaudy.—An illustrated collection of useful information regarding many of the common applications of electricity in the household, including over 50 pp. dealing with electric lighting

(To both of the above we hope to make more detailed reference shortly.)

The Evaluation of Lamp Life. By P. S. Millar and L. J. Lewinson.—A paper presented at the fifth annual convention of the Illuminating Engineering Society in America, in which some new suggestions are put forward as to the determination of the "smashing point" of glow lamps.

Arc Lamps for Projection. By H. P. Gage.—A reprint from the *Electrical World*, containing the results of some experiments carried out by the author on several different types of projector arc.

The Radiant Efficiency of Arc Lamps. By H. P. Gage.—An account of an investigation undertaken with a view to determining the radiant efficiency and the mechanical equivalent of the light from the right angle carbon arc and the Bremer flame arc.

A Study of the Current Transformer with Particular Reference to Iron Loss. By P. G. Agnew.—Reprinted from the *Bulletin* of the Bureau of Standards, Washington, U.S.A.

We have also to acknowldege the recepit of the following: *Journal of the Royal Sanitary Institute, Journal of the Royal Society of Arts, Journal of the Rontgen Society, Transactions of the Iron and Steel Institute, Transactions of the South African Institute of Electrical Engineers, of the American Institute of Electrical Engineers, Physical Review, Journal of the Franklin Institute, Zeitschrift für wissenschaftliche Photographie Photophysik und Photochemie.*

Illumination: its Distribution and Measurement.

By **ALEXANDER PELHAM TROTTER.** Illustrated. 8vo, 8*s.* 6*d.* net.

Electricity.—"Contains a wealth of experience and practical information, and comes at the moment when a work on the subject by a British engineer is much needed."

The English Mechanic.—"Many readers will be glad to get this book which really supplies "a real want.....As an intelligent record of the work achieved by the "old masters" of photometry of the writer's own investigations, we heartily recommend the book to all interested."

MACMILLAN & CO., LTD., LONDON.

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The ELECTRICITY · ACETYLENE · OIL · GAS
ILLUMINATING ENGINEER
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
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Tel. No. 5215 Westminster.

EDITORIAL.

Progress of the Illuminating Engineering Society during the Vacation.

THE summary of progress during the vacation, which was presented previous to Dr. Hickman's paper at the opening meeting of the Illuminating Engineering Society on Nov. 17th, will doubtless be read with pleasure by members of the Society. There is no need to review the different items included in the report in any detail now. An opportunity of doing this will be afforded when the Report of the Council comes to be issued at the conclusion of the Session.

The various steps that have been taken serve to show the steady influence it is exerting on public opinion, and the willing co-operation which it has received from other older established outside bodies. Many of these steps would have been considered almost impossible at the time the Society was started.

The success so far attained in these directions is due mainly to the gradual recognition that the motives of the Society are good, and that in pursuing its objects it has striven from the first to act with moderation. From the very beginning it was recognized that, in order to meet with enduring success, the progress of such a movement must be slow but sure.

It need not be said that much prudence and determination will be needed in order to carry on the work to a successful conclusion. Meantime it is hoped that members will continue to take every opportunity of making the aims of the Society known, and of increasing its strength numerically.

The Design of Motor Car Headlights.

The paper by Dr. Hickman on this subject deserves special attention from those interested in the motor industry. The design of headlights has become a highly specialized business, and very much more care is now given to this subject than a few years ago. A paper summarizing in such an able manner the chief points to be observed in reducing glare to a minimum, and distributing the light as perfectly as possible, is, therefore, very opportune at the present moment, and we cannot recall any previous paper which covered the ground in this comprehensive way.

To the Illuminating Engineering Society the paper is of exceptional interest, coming as it does after the previous discussions on glare, and at a time when street lighting is receiving so much attention. Many of the difficulties encountered in designing motor car headlights are not dissimilar from those met with in lighting streets. In both cases we have the necessity of providing a much stronger illumination than would have sufficed a few years ago, largely owing to the speeding up of the traffic. In both cases, too, we have to reconcile the avoidance of glare, and the proper distribution of light—a matter of no little difficulty which requires careful study. Drivers of motor cars desire to be able to see distant objects clearly, and this may demand the use of powerful illuminants, but it is necessary to point out that if such illuminants are wrongly placed, so as to produce a dazzling effect, they may be a grave inconvenience instead of an assistance.

These matters naturally fall within the province of the authorities concerned with the direction of traffic. As in the previous discussion on glare, therefore, their attention was drawn to this discussion on Motor Car Headlights, and the existing regulations affecting the lighting of vehicles was commented upon in the course of the evening.

It is of interest to see that adequate lighting and absence of glare are required in general terms. On the other hand we are still faced by the difficulty of deciding what exactly is meant by "adequate lighting" and under what conditions can a headlight be said to be unduly "dazzling." Our ideas on these points are certainly much clearer than they used to be, and it should not be impossible at this stage to devise more precise definitions and tests which would serve to clear up this uncertainty. The matter is surely of importance to motorists, and is also of considerable interest to lighting engineers. The Royal Automobile Club organized a valuable series of tests of headlights in 1909, and it would be beneficial if they would carry these tests a little further so as to make more precise recommendations on the subject of glare. No doubt the Illuminating Engineering Society would be glad to give assistance in this matter.

The Motor Car Exhibition.

In this number we also publish a summary of the chief points of interest in the recent motor exhibition at Olympia. The section of the exhibits which probably made the most direct appeal to our readers was that devoted to motor car lighting systems and headlights. It is remarkable in how short a time this business of providing light for cars has become an important section of the motor industry. Much ingenuity has been shown in the many different systems, both electric and acetylene, now available, and a great deal of technical skill has also been lavished on the design of the mirror and lens systems of modern headlights. Such lamps may be regarded as an excellent example of the combined efforts of the optical and lighting expert.

There are, of course, other opportunities for illuminating engineering in connexion with motor cars. Medical men and others who use their cars

largely for professional purposes are well aware of the convenience of having good artificial light inside the car so that they can study their notes, &c., while on their way to a visit. It is interesting to see that interior lighting is now made a special feature in many cars, small lamps equipped with diffusing or prismatic glass hemispheres being fitted into the roof.

From the driver's standpoint the provision of adequate lighting in the front of the car is also an important matter. It is essential that he should be able to see the various levers, the lubrication, and the dials on the switchboard, &c., and small screened tubular lamps are now very frequently fitted up to enable him to do so. Another convenient accessory now provided is a small portable lamp (equipped either with a self-contained acetylene generator or with a flexible lead by which a small glowlamp can be connected to the electric battery); this enables the driver to examine the mechanism of any part of the car in the event of anything going wrong. In such lamps the actual flame or filament should be screened from the observer's eye, and a reflector provided to throw all the available light on the object viewed.

In our article on this subject some reference is also made to the methods of illumination employed at Olympia for lighting the hall and the stands of exhibitors. Naturally at a motor exhibition lighting plays a secondary part. It is simply a means of displaying the exhibits, and not, as in the case of the electrical exhibition, an exhibit itself. It may be said, however, that from the illuminating engineering standpoint the methods adopted at the motor show were in the main satisfactory (although naturally capable of improvement). The arrangement of the luminous signs at each stand, high up above the cars, was a good feature, and in comparatively few cases was there much to complain about in the matter of glare. Many of the signs, too, showed a certain skill in their design even if the arrangement of the reflectors to illuminate them was sometimes rather primitive.

A specially commendable feature was the series of illuminated tablets opposite each gangway on which the names and numbers of the various stands were clearly shown, and which enabled the visitor readily to locate any exhibit in which he was specially interested.

The Study of Daylight Illumination.

The article on page 669 in this number summarizes some of the interesting investigations on daylight illumination carried out by Prof. L. Weber in Kiel during the last five years. Prof. Weber, as is well known, has made a special study of this subject, much of his early pioneering work having been carried out as far back as 1890.

The amount of study necessary in framing recommendations on daylight illumination is possibly even greater than in the case of artificial light, for we have not only the local requirements and the nature of the interior to be illuminated to consider. We must also take into account the conditions outside (*e.g.*, the amount of obstruction from adjacent trees and buildings, &c.), and we must make a further allowance for the variations in climatic conditions during the year. Thus an interior which might be considered quite satisfactorily lighted on a bright day in June might yet be very poorly illuminated on a dark day in January. Prof. Weber, in studying the conditions in the schools of Kiel, has therefore undertaken a most exhaustive series of investigations, extending over five years, as a result of which the average conditions on any day can be estimated. In addition to this the distribution of light in the rooms has been investigated, and the desks

grouped according to the illumination they receive. By the aid of these two sets of data, one can form a very good judgment regarding the admission of daylight into any particular room.

The second part of the paper deals with the specification of window space. We are familiar with the simple rule followed by architects, that the window area should be not less than one-fifth of that of the floor. It is clear, however, that although this may serve as a rough guide it does not take into account the local conditions very fully. For example, as Prof. Weber points out, it says nothing of the effect of obstructions outside of the window and the amount of sky visible. Nor does it allow for the fact that the recessing of some windows, especially the casement windows in many old buildings, very materially affects their value for admitting light. Again the height and depth of the room (apart from its area) are important points to consider.

These different items are much better allowed for by also observing the "light-value" of the window (*i.e.*, the percentage of its area which is unobstructed by trees, buildings, &c.) from different parts of the room. One ought, if possible, to secure that this does not fall below a certain minimum value even in the darkest part, and Prof. Weber suggests a new factor in which both this quantity and the conventional ratio of window area to floor surface are incorporated. He has also devised special apparatus for determining the light-value of windows.

The majority of the schoolrooms tested by Prof. Weber appear to have been lighted fairly well. On the other hand, he found that the daylight illumination in the library of the University of Kiel was quite inadequate, and is disposed to think that the same would apply to many existing libraries. No doubt in those now being built better provision for daylight is made. We can, however, recall some of the older and more famous ones in which the admission of daylight is admittedly inadequate judging by modern standards. In some of these cases the interior is of a venerable and artistic character; the windows are comparatively small, and are composed of coloured glass of ancient design, which obstructs a great deal of light. Naturally there is a reluctance to make any modifications which would destroy the artistic appearance and historical associations of these old buildings. If, however, they are to be constantly used for reading one may recommend that special pains should be taken to ensure that the artificial lighting (on which students in the library are largely dependent) should be as satisfactory as possible.

While mentioning this matter we may draw attention to the reference in this number (on p. 679) to the examinations in sanitary science and hygiene promoted under the auspices of the Royal Sanitary Institute. It is gratifying to observe that day and artificial lighting forms an integral part of the syllabus of these examinations, and we suggest that it would be well if this were supplemented by some reference to the measurement of illumination.

This is a subject on which we have frequently received inquiries from school and sanitary officers. As we have had occasion to point out previously, there are now available a number of simple instruments for measuring artificial illumination, and Prof. Weber has shown how valuable apparatus for measuring daylight illumination and available window space may be. We commend this paper to the notice of architects, medical officers of schools, and others closely concerned with these problems.

LEON GASTER.

Review of Contents of this Issue.

THE technical section opens with an article on **The Study of Daylight Illumination in Kiel,** in which some account is given of the recent work of PROF. DR. L. WEBER. After a brief reference to his early work in this direction, the exhaustive research undertaken by Prof. Weber during the years 1905–8 is described, and a curve is given showing the variation of average daylight illumination during each month of the year, based on these recent tests. Some suggestions are made as to improving the existing rules concerning window area in rooms. In addition to the rough rule that the ratio of window area to floor area should not exceed about 1 : 5, Prof. Weber proposes to use a quantity L, the "light value" of the window, which he defines as the solid angle subtended by the unobstructed window area at a given position expressed as a percentage of what it would be if the window were entirely open to the sky. This quantity, multiplied by the ratio mentioned above, gives a new figure which forms a very fair criterion of the value of the window. This figure has been determined for various schoolrooms and for the University Library at Kiel, and with the available data as to variation of daylight, it is possible to predict with some certainty the likely illumination on a desk in a certain position at a given time.

A summary of a paper by A. HESS on the **Use of Series Arclamps on a High Tension Installation** is given on p. 673. This paper was presented at the Electrical Congress at Turin, and describes an installation that was carried out at the exhibition held there during the summer. The lamps were arranged in two series of 120 each, the voltage of the circuits being 6,300. Special substitution resistances were built into each lamp, so that in the case of the failure of one, the whole series was not extinguished. The installation was economical, and appears to have given general satisfaction.

On p. 675 is given some account of the course of **Lectures on Illuminating Engineering** at Regent Street and Battersea Polytechnics, to which reference was made in our last issue. The lectures given at Battersea Polytechnic by Prof. J. T. Morris and Mr. J. G. Clark were repeated, followed by a lecture on Oil, Acetylene, and Petrol air-gas Lighting by Mr. E. Scott Snell, and one by Dr. W. J. Ettles on Illumination and the Eye. A photograph is given showing the appearance of the lecture hall on the night of the opening lecture.

A description of the **Indirect Gas Lighting Installation** in the offices of the Indianapolis Gas Co. will be found on p. 680. An illustration is given of the four-light fittings which have been adopted in most of the rooms. The decoration of rooms was designed with a view to the indirect system, and the ceilings and friezes are of light tint throughout.

The section of the magazine devoted to the Transactions of the **Illuminating Engineering Society** (p. 681) opens with an account of the first meeting of the new session, which was held on Nov. 17th, and this is followed by a list of names of applicants for membership during the vacation. A feature of this list is the large number of Continental authorities who have joined the Society, and thus add to its international and representative character.

A brief report of **Progress during the Vacation,** which was presented by the Hon. Secretary, will be found on p. 684. A reference is first made to the formation of committees on School and Library Lighting, and the names of the gentlemen constituting these committees are given. The official representation of the Illuminating Engineering Society at the Congress of the Royal Sanitary Institute and at the Hygienic Exhibition in Dresden is also referred to, and the interest shown in the subject of illumination in

both cases is mentioned as a gratifying feature. Attention is then drawn to the important State Committee on the Hygienic Aspects of Lighting recently appointed in France, and it is mentioned that the Home Office in this country is now understood to be giving consideration to the subject. The recognition by the International Electrotechnical Commission, and by the International Electrical Congress meeting at Turin, of the international and impartial status of the Society is evidenced by the two important resolutions which were passed by them, and have previously been reported in the journal. In conclusion, the report briefly refers to the courses of lectures on illuminating engineering which have been arranged by the London County Council Education Department, and are now taking place at the Regent Street and Battersea Polytechnics.

A paper entitled **Notes on the Design of Motor-Car Headlights** read by DR. H. R. B. HICKMAN at the opening meeting, is printed *in extenso* on p. 687. The author mentions some of the difficulties met with in driving at night, such as turning corners, meeting other cars, cyclists, or pedestrians, and he then proceeds to describe the conditions that should be complied with by an ideal headlight. The optical principles of the various types of headlight at present in use are referred to in some detail, and in conclusion a number of special devices for the prevention of glare and dazzle are described.

In the discussion which followed, the Chairman MR. F. W. GOODENOUGH emphasized the fact that the lighting of the car should indicate its extreme width. MAJOR HERBERT described a form of swivel headlight which he had designed, and said that he did not think the regulation forbidding such headlights would be enforced. MR. A. P. Trotter discussed the definition of "glare," and drew attention to the effect of headlights when a car was moving on an incline. MR. W. F. REID referred to the question of light reflected from fog or mist. MR. L. GASTER drew attention to the police regulations forbidding unduly dazzling headlights and demanding effective lighting. He hoped that the qualifications required might shortly be made more definite. Mr. Gaster also referred to some tests carried out on American railways which served to show the importance of bearing in mind the dazzling effect of very bright opposing headlights. MR. K. EDGCUMBE asked if Dr. Hickman had actually tried the effect of crossing the headlight beams on a bank of fog. MR. V. H. MACKINNEY demonstrated, by means of two lamps projected on to a screen, how a suitable arrangement of cylindrical lenses could be made to produce a rectangular and uniform patch of light, which he thought was what was really required for lighting the road in front of a car. Mr. C. W. S. CRAWLEY spoke of the regulation forbidding swivelling headlights, and said that the Royal Automobile Club did not consider such lamps illegal. MR. H. S. RYLAND spoke of the importance of securing a small concentrated source of light, and also suggested the application of the principle of the optical lantern to the production of a homogeneous beam. The discussion concluded with a brief reply from DR. HICKMAN.

A description of some of the special features of the recent **Motor-Car Exhibition** at Olympia from the standpoint of the illuminating engineer, will be found on p. 704. The article first discusses the general arrangement of the lighting of the show, and in particular the system of illuminated signs employed to indicate the various stalls and sections, which are dealt with in some detail. Following this is a description of some of the acetylene and electric plants for the lighting of cars, and the article concludes with an account of some typical motor-car headlights.

At the conclusion of the number will be found the usual **Short Notes on Illuminating Engineering**, the **Trade Notes**, and the **Review of the Technical Press.**

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

The Study of Daylight Illumination in Kiel.*

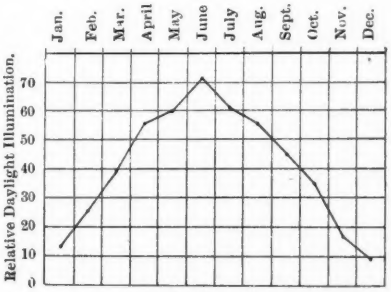
By Prof. Dr. L. Weber.

Readers of this journal are aware of the considerable amount of early work carried out in connexion with the study of daylight illumination by Prof. L. Weber, some of these tests having been undertaken as early as 1890.

We have now before us a series of additional results derived from measurements carried out between 1905 and 1908. These data lead to some striking suggestions regarding the specification of window-space in interiors. In his opening remarks in this paper Prof. Weber recalls that periodical tests of daylight illumination have been carried out by photographic methods by Dr. H. Koenig in Mecklenburg and Dr. K. Moeller has also attempted to use the selenium cell for this purpose. This last method, however, is not considered quite reliable enough for practical purposes as yet.

During the years 1905–8, Prof. Weber has carried out a complete survey of the intensity of daylight illumination, as measured daily at mid-day throughout the year. For this purpose a little house was built having in its roof a ground opal glass plate which received the full daylight illumination; the surface brightness of this was measured from below. Comparative measurements throughout the year are thus possible, and the results obtained are summarized in an exhaustive table. The brightest conditions were observed in June, the dullest in December. Taking the average during these four years the minimum value of the illumination is *less than one-hundredth* of the maximum value, while the average illumination in June is about nine times that in December. It will be seen, therefore, how vast is the variation in daylight under different conditions, and how essential it is to provide ample means for the admission of light so as to allow for the worst conditions likely to occur.

The following curve shows the variation in the average illumination during each month throughout the year, based on these recent and exhaustive tests.



Variation of Daylight Illumination throughout the year.

Specification of Requisite Window Area.

It will next be convenient to refer to Prof. Weber's suggestions as to improvements in the existing regulations on the subject of minimum window-space.

* Reprinted from *Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein*, Band xiv., Heft 2.

The rough rule first prescribed by authorities was that the ratio of area of windows to area of floor should not exceed a certain value (1·5 in some cases, 1·10 in others).

As a first step in the right direction this was valuable, but it is obvious that the specification of window area alone is not sufficient. An equally important question is how much daylight can enter through the window, *i.e.*, to what extent is the sky obstructed by neighbouring trees, houses, &c. This being recognized, the original recommendations were soon supplemented by more complicated directions regarding the minimum width of street, maximum height of houses opposite, minimum free distance sideways, &c.

But the shape, depth, and height of the room, and the position of desks and tables in it with regard to the window should also be borne in mind. Prof. Weber has therefore been in the habit of specifying the solid angle subtended by the window in these positions. For instance, earlier researches by Cohn and himself have shown that if this quantity is not less than 50 degrees in school-rooms, the illumination on the desk would in general not fall below 25 metre-candles (approx. 2½ foot-candles).

If this quantity is modified so as to include the percentage of the window area, through which unobstructed sky can be seen, it becomes even more useful. Prof. Weber has therefore defined the "light-value" ("Licht güte" denoted by L) of a window as follows:—The Light-value gives, as a percentage, the value of the solid angle subtended by the unobstructed area of the sky, as seen through the vertical window; the corresponding solid angle with an entirely unobstructed window being taken as 100.

If now we multiply L by the permissible ratio of window space to floor area we obtain a new quantity, P, which is a very serviceable expression of the usefulness of a window for admitting daylight. Having determined L, we have $P=\frac{L.\ g}{b}$ where g is the area of the glass surface of the window and b the area of the floor of the room. Prof. Weber proceeds to describe two simple forms of apparatus by means of which an image of the window can be thrown upon a white surface, and its "Light-value" readily obtained. He also gives examples of methods of treating a group of windows together, so as to reduce the labour of working out L for each of a very large number.

In order to decide what value P should have in the case of various rooms further data are desirable, but these could be readily determined. As example of the values commonly reached the author gives an account of some investigations in school-rooms and libraries.

Conditions of Illumination in Schoolrooms in Kiel.

By studying the illumination in different classrooms, and by the aid of the complete data now available on the variation of the light at different periods of the year, it is possible to predict with some certitude what the illumination on a certain desk in a given room at any particular time should be. As mentioned above, it had previously been ascertained that the window area should subtend an angle of at least 50 degrees at a desk, in order that an illumination of 25 metre-candles may be relied upon. This, however, says nothing as to the effect of adjacent buildings, &c., in blocking out the sky, and so reducing the light. Prof. Weber summarizes the results of investigations in 620 classrooms. In each of the rooms the illumination on the brightest and darkest desks and a desk in an intermediate position (respectively 1, 3, and 5 metres from the window) was studied. It is remarkable how rapidly the light falls off, the three desks receiving in general light in the proportion of 100, 30, and 11, respectively. He found that in the case of 171 rooms, P was 10, in 304 rooms P lay between 5 and 10, and in 45 rooms only was P less than 5. Between these limits it is estimated that the desks of the second order should receive about 250 to 150 metre-candles, and those on the third order between

100 and 50, assuming an average sky brightness of 10,000 secondary units (metre candles).

If, however, one takes the month of December, this sky brightness ought, properly speaking, to be reduced to one-fifth and the illumination correspondingly reduced. In deciding which rooms are to be considered insufficiently lighted one must, of course, bear in mind the local climatic conditions and hours of study to some extent. (An extreme case would be presented by those schools in parts of Finland where the sun never rises at all for several months in the year !—ED.)

It was also found that there were 297 classrooms in which all three grades of desks received more than 50 degrees of sky, 208 classrooms in which the requirements in this respect for the worst lighted desk would not suffice, and 15 classrooms in which even the intermediate grade of desk was not sufficiently lighted.

As a means of improving the conditions in poorly lighted schoolrooms, the author suggests whitening the walls of surrounding buildings, removing trees which obstruct too much of the sky, and utilizing as light a scheme of decoration as possible for the walls of the class room.

MEASUREMENTS IN THE LIBRARY OF THE UNIVERSITY OF KIEL.

A study of the conditions of daylight prevailing in the libraries would probably show that only in comparatively few cases could the light during the winter months be considered adequate.

Prof. Weber gives the results of an examination of the illumination of the library of the University of Kiel on a fairly bright day in April. Under these conditions the illumination on the tables was found to vary from 4·4 to 30·6 metre-candles, while there was one place so dark (receiving under 1 metre-candle) that no measurement could be made. Seeing that the minimum illumination prescribed is 25 metre-candles it is evident that most of the tables would be insufficiently illuminated even on this comparatively bright day. With the average sky-brightness during the year the best illuminated place would receive 16·8 foot-candles, and the worst 2·4. In December, on the other hand, even the best illuminated table would only receive 3·2 metre-candles.

The conditions of illumination of the shelves were likewise deficient. On the day specified the illumination was in many cases under 25 metre-candles, while in December all the shelves would fall below this value.

In general it is probable that the great majority of stacks of books rising to the ceiling are insufficiently lighted. This library also serves to show that the old rule about specifying the window-area per foot of floor is inapplicable. For in this library this ratio works out to about 1:3 (*i.e.*, *twice* as much as the most severe regulation of this kind demands), and yet the illumination was not enough. One thing to be noted is that when the bulk of the floor is occupied by stacks of books, the total area to be illuminated is really much greater than that of the floor. It was also ascertained that the fact of the windows being recessed alone caused a loss of about a third of the light from the sky, and the effect of adjacent trees and buildings is such that in summer the light-value of the window is only about 34 per cent.

In the schoolrooms referred to previously a satisfactory illumination was secured when P attained the value of 10 per cent, and an unusually bright illumination when it was of the order of 16 to 20 per cent. When properly estimated P, in the case of this library, only reaches the unsatisfactory figure of between 2 and 3 per cent.

A study of other libraries of this kind would doubtless yield interesting comparative results.

The Distribution of Brightness in the Sky.

By H. Borchardt.

An interesting contribution to the theory of sky-brightness by H. Borchardt is also reproduced along with the data of Prof. Weber.

The paper contains some rather abstruse investigations into the scientific basis of the subject, including a summary of the theoretical work of Rayleigh, Clausius, and others, and of the practical investigations by Weber and Schramm. Some striking diagrams, comparing the distribution and intensity during the twelve months of the year, are included.

The chief practical conclusion is that it is only rarely that the sky can be treated as a diffusely radiating hemisphere as habitually assumed in calculations of illumination from the known sky-brightness. As a rule, the brightness at the zenith and on the horizon are very different, and the sky probably consists in a mixture of diffused and directly transmitted light.

The International Petroleum Congress.

to be held in Vienna, Jan. 16th—22nd, 1912.

With a view to making preparations for the forthcoming General Meeting of the International Petroleum Commission (the headquarters of which are in Karlsruhe), a meeting of the representatives of the various national committees took place in Vienna on Oct. 14th. The Chairman on this occasion was K.K. Sektionschef Dr. Brosche, and among those present were Hofrat Ritter von Kreutzbruck, General Secretary of the International Commission, Dr. Ubbelohde (Karlsruhe), Direktor Neurath, Dr. Max Böhm (Mähr, Ostrau), Direktor Dr. L. Singer (Pardubitz), Prof. Zaloziecki (Lemberg), Prof. Ing. Klaudy (Vienna), Dr. Wolny, Secretary, and Ing. R. A. Schwarz (Vienna).

It was resolved that the General Congress should be held in Vienna on Jan. 16th—22nd, as stated above, and that the meetings should be held in the House of the Ingenieur- and Architekten-Verein.

It was further decided that the proceedings should consist partly in general meetings and partly in sectional meeting, dealing respectively with standard methods of testing, scientific definitions and nomenclature and storage, transport and safety from fire respectively. It is hoped that as a result of the deliberations in this last section propositions for the eventual revision of the regulations affecting the transport of mineral oil will be evolved, and that the question of transport on board ship will receive special study. Besides the national sections, various other important bodies interested will be represented.

Meanwhile meetings of the various National Committees have already taken place (the German section having met in Munich on Nov. 16th—18th, and the French section in Paris on Oct. 20th), and in most of the other countries participating, the arrangements are well advanced, so that definite conclusions from the work of the Commission may be expected at the coming Congress in Vienna.

The programme of entertainments has been placed in the hands of the section for Austria-Hungary. It will include an official reception and other functions, and excursions to the new mineral oil works at Drohobycz, the mines at Tustanowice, and elsewhere are contemplated.

The Use of Series Arclamps on a High Tension Installation.

By A. Hess.

(Paper presented at the International Electrical Congress held in Turin, September 10th–17th.)

In his paper on this subject Mr. Hess commenced by referring to the recent progress in arclamp manufacture. In the latest forms a specific consumption as low as 0·15 watts per c.-p. has been obtained.

But in addition to developments in the arclamp itself efforts have been made to improve the conditions in which they are used—to economise in the installation part of the lighting system. It is well known that on ordinary constant potential circuits there is an inevitable but considerable waste of power in the series resistance added to the lamps. In Germany, France, and the United States the method of running 40 or 50 lamps in series on a constant current circuit, and on a high p.d. of 2,000–2,500 volts has been recently largely adopted, since it leads to a considerable saving, particularly as regards the amount of copper used in the mains.

As a result of a conversation with Herr Rosemeyer of the Regina Electrical Co. in Cöln-Sülz (to whom we are indebted for the illustration accompanying this article), the author conceived the idea of a 3 phase installation of series lamps on 6,300 volts at the Turin Exhibition. When, however, the plan was first suggested to the Committee of the Exhibition the scheme was considered impracticable. Eventually, however, these difficulties were overcome. The lamps have been installed, and have worked quite satisfactorily for three months.

The conditions which must be complied with in an installation of this kind are as follows :—

1. The lamps used must have satisfactory mechanical regulation, independent of all sudden changes in p.d. or current.

2. Special means must be provided in order to secure that the failure of a single lamp does not lead to the extinction of the entire series.

3. A satisfactory method of uncoupling lamps must be used, so that they can be lowered and attended to even while in actual use.

4. There must be means of insulating the parts carrying the current from each other and from earth ; there must also be means of earthing the system as a whole so as to avoid all possibility of danger from shock.

The first of these conditions was complied with by the Conta lamp of the Regina Co.*

The second condition is satisfied by building into each lamp special substitution resistances ; in an emergency these can carry the full current, but while the lamp is in action only a small fraction of the total current, about 1·5 amperes, will pass through.

The third condition is complied with by a special form of mechanism designed for the purpose ; satisfactory methods of earthing the entire system have also been applied.

The installation at the Exhibition comprised 240 lamps each consuming 10 amperes and furnishing 2,400 c.-p. ; these lamps are arranged in two series of 120. The distribution of current is effected by about 5 kilometres of underground armoured and paper-insulated cables. The lamps are grouped at two heights respectively 6 and 15 metres, the substitution resistances being placed at the former height from the ground.

* For an account of the simple method of control employed in this lamp, see an article on the subject by Prof. G. Bermbach, *Illum. Eng.*, Lond., vol. iii., 1910, p. 19.

Experience has shown that had this system been arranged on the usual low tension methods the extra cost per lamp in copper would have been 60 francs for mains alone. The cost of running the entire system for an evening of four hours is 60 francs (30 for carbons and 30 for electricity). This is equivalent to about 6 centimes per lamp-hour.

These data may serve to show that the method of arranging lamps in series on a high voltage has not yet reached its limits. Possibly in the case of ordinary street lighting one would not desire to carry the voltage as high as in this case, but the favourable experience on this occasion shows the safety of the method.

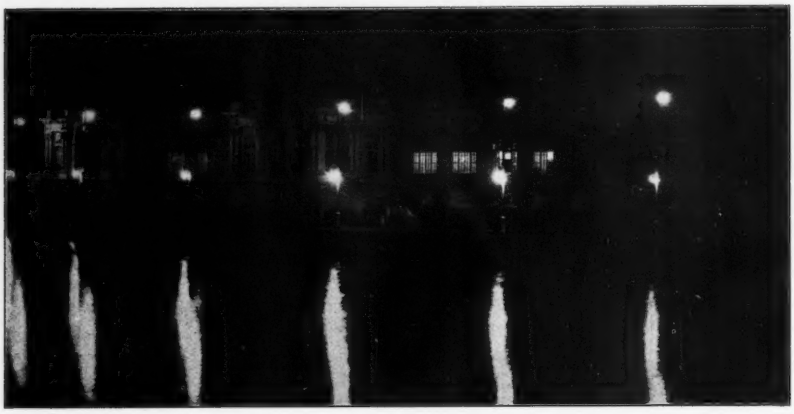


FIG. 1.—Showing arrangement of Conta Lamps on 6,300 v. series installation at the Turin Congress.

In conclusion special thanks are due to Signor Giovara, Head of the Engineering Department of the Exhibition, to whose efforts the success of the installation has been largely due.

The Early History of the South Metropolitan Gas Co.

SOME interesting particulars of the early history of this company, which was formed about 1829 for the purpose of supplying gas made from cannel coal in South London, are given in a recent number of *The Copartnership Journal*. The company had then to compete with the Phœnix Co., but it was thought that the very rich quality of gas manufactured would enable this to be done successfully. The price charged for gas was, however, very high, judging by modern standards, being as much as eleven shillings per thousand cubic feet. The works were less than three acres in extent when opened in 1833, and the first gas-holder, erected in this year was only fifty feet in diameter and 18 ft. high. By 1836, however, it appears that the maximum daily demand was as much as 150,000 cubic feet.

In view of the vast developments of the business of the South Metropolitan Gas Co. at the present day it is very interesting to hear of these early beginnings.

Lectures on Illuminating Engineering.

THE course of lectures arranged at Regent Street and Battersea Polytechnic Institutions have been proceeding during the course of the last month. In our last number we gave a short account of the two opening lectures at the former institution by Prof. J. T. Morris. These two lectures were repeated at Regent Street on Oct. 31st and Nov. 7th.

Fig. 1 is a view of the lecture room at Regent Street Polytechnic taken entirely by artificial light on the evening of Prof. Morris's first lecture.

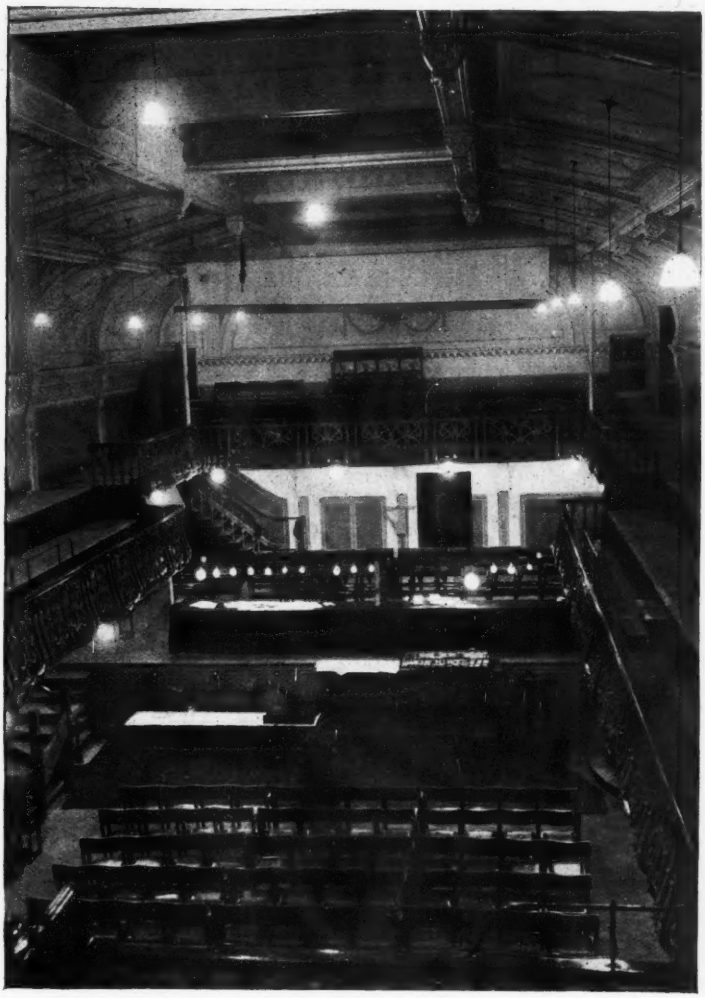


FIG. 1.—Photograph taken by artificial light in the Large Hall at the Regent Street Polytechnic, London, on the occasion of the first of the series of lectures on Illuminating Engineering.

Fig. 2 is also interesting. It is a photograph taken in the lecture theatre of one of the tables thrown on the screen by the lecturer, and suggests a possible means of recording illustrations of this description at lectures.

Lectures have also been delivered by Mr. J. G. Clark and Mr. E. Scott Snell and Dr. W. Ettles respectively, the last-named bringing the first series of six lectures at Battersea to a close.

Gas Lighting.

Mr. Clark's lectures on gas lighting have now been delivered at both institutions. The first lecture was concerned mainly with fundamental principles and with ordinary low-pressure lighting.

Dealing first with the general principles of gas manufacture and distribution, and with the heating and lighting properties of the various constituents of illuminating gas, the lecturer passed on to the development of gas lighting from its early days to most recent times; the economical value of this development being shown in diagrammatic form.

The change from luminous flames to the incandescent mantle was then described, and it was pointed out that the light produced was in each case due to incandescent solids; in the first case, the light was derived almost entirely from incandescent carbon in the flame; whereas, in the second case, it was derived from the incandescence of the oxides of thoria and ceria.

The Bunsen burner and structure of the bunsen flame were then explained, and the important connection between flame temperature and luminous emissivity from the incandescent mantle was pointed out. It was shown that the important difference between the luminous and Bunsen flame was that in the former case the combustion was made to take place slowly; whereas, in the latter case, it was accelerated by the induction of air into the Bunsen tube before combustion. The lecturer also called attention to the difference between the so-called solid and hollow flames.

Upright, inverted, horizontal, and inclined burners were next dealt with, and it was pointed out that the two last-named were not very much used in this country. The "Metrolite" burner was shown to be a combination of the inclined and inverted systems. Stress was laid on the superiority of the inverted system in regard to efficiency, luminous distribution, appearance, and maintenance.

The manufacture of the incandescent mantle was then briefly explained. Methods of determining their value in regard to strength, lighting efficiency, and durability were described, and the artificial silk and solid-filament mantles were shown together with micro-photographs illustrating their structure.

In conclusion, a number of typical inverted burners and low-pressure units were shown to the audience, and their special features explained.

The second lecture dealt first with the various methods of producing high-power gas lighting units.

Self-intensification on the induction principle was described, and specimens of the lamps were displayed for inspection.

The various mechanical methods of self-intensification were then described, viz., the Thermopile, Chipperfield, and Scott-Snell lamps. The principle of the Thermopile lamp was explained by means of diagrams and models, and a Chipperfield lamp was shown in actual operation.

The application of the induction method of self-intensification to the inverted burner was explained, and some typical lamps shown as examples. These lamps, it was stated, are made in several sizes, viz., 500, 750, and 1,000 candle-power units, and have efficiencies of 40 candles per cubic foot per hour and over. Ventilating gas lamps and their applications were then alluded to, and illustrated diagrammatically.

High-pressure systems were next dealt with and various appliances were described by means of actual machines and diagrams. It was pointed out that the scientific application of preheating of the mixture before combustion was an important feature. Units of from 60 to 4,500 candles are procur-

able in this way, with an efficiency of 60 candles and more per cubic foot of gas per hour consumed.

The applications of these high-power units to public and shop front lighting was then described with the aid of photographs. An illustration of the centrally suspended system of street lighting by gas was also shown, and the method of raising and lowering described. Public lighting by low-pressure gas was also dealt with, and some interesting photographs shown.

Other systems of pressure intensification, viz., high-pressure air and high-pressure mixtures of air and gas, were next discussed.

The various systems of automatic control of public lamps, both high and low pressure, were then described by means of models and slides. Three principles were illustrated, viz., clockwork, pressure, and pressure-clockwork. The clockwork system can be used in shops to extinguish the gas at a certain hour. Distance ignition was next dealt with. Various methods were described, including the electric "Telephos" and pneumatic apparatus. Gas-pressure systems were next mentioned. The Bamag apparatus, by the aid of which street lamps can readily be controlled from a distance, was described as an example of these methods; self-lighting mantles and pyrophoric lighters were also touched upon.

The lecturer then discussed some questions relating to the heating value of gas, and pointed out some phenomena which may have some influence on the future development of incandescent lighting, viz., surface combustion and catalysis. It was also mentioned that further study of the relation of the mantle to the heat zones of the flame may lead to still further improvements.

The legal standards of gas supply were then referred to, and it was pointed out that progress was being made towards dealing with gaseous fuel on an energy or calorific basis.

Thanks are due to a number of firms who contributed towards the success of these lectures by the loan of gas appliances.

To Messrs. The Gas Light & Coke Co. for the loan of a number of lamps and burners, including the Nico, Sugg, Sylva, Podmore, and Lucas lamps, and Bland, Nico, Hands, and Bray inverted burners, &c.

Also to the following firms, by whom well-known lamps and appliances were shown: Messrs. Jas. Keith & Blackman Co., Ltd., W. Sugg & Co., Ltd., Tilley Bros., The Pneumatic Gas Lighting Co., The Telephos Domestic & Street Lighting Co., Ltd., The Auto Lighter, Ltd., The Chipperfield Lamp Syndicate, Thomas Glover & Co.

Oil, Petrol Air-Gas and Acetylene Lighting.

On Tuesday, Nov. 14th, Mr. E. Scott-Snell gave the fifth of the series of lectures on Illuminating Engineering at Battersea Polytechnic, dealing with what may be regarded as the self-contained systems of lighting, viz., those systems whose special province is those districts which are outside the reach of electricity or coal gas mains. This lecture was repeated on Nov. 28th at Regent Street Polytechnic.

A large number of slides were shown, including sections and diagrams, showing the working of incandescent oil lamps; oil-gas, acetylene, and petrol gas generators; gas buoys, &c., and demonstrations were given with representative types of most of the systems. Thus the lecturer described the action of the Blanchard incandescent paraffin table lamps (kindly lent by the Gas Economizing & Improved Light Syndicate); a portable lamp for use with acetylene (made by the Allen Acetylene Co.) was also shown. The convenience and simplicity of a dissolved acetylene outfit for motor-car lighting, &c. (lent by the Acetylene Illuminating Co., Ltd.) was next described, and the lecturer subsequently explained the working of an excellent model of the automatic acetylene buoy of the International Marine Signal Co., pointing out its use in remote situations.

In conclusion, Mr. Scott-Snell expressed his thanks to the County Light, Ltd., who had been good enough to set up a complete 25-light weight-driven petrol air-gas generator in full working order.

This plant was shown in actual work at the end of the lecture, and reference was made to the widespread use of petrol-air-gas plants in country houses; while on the Continent it had even become usual to light small towns in this manner.

Illumination and The Eye.

A lecture at Battersea Polytechnic on 'Illumination and the Eye' was delivered by Dr. W. Ettles at Battersea Polytechnic on Tuesday, Nov. 21st. This lecture will again be delivered at Regent Street on Dec. 5th.

Dr. Ettles commenced by explaining how many primitive forms of life showed their perception of light by means quite distinct from vision as we understand it. He then passed on to the structure of the human eye, which he described very fully by the aid of a series of lantern slides.

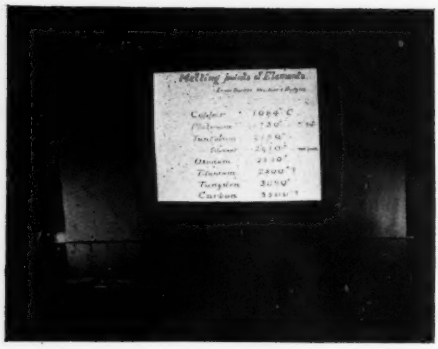


Fig. 2.—Photograph of diagram thrown on the screen (taken while the lecture was in progress, the exposure being determined with the Holophane Lumeter).

After explaining the nature of the lens and the muscles controlling it, he showed a striking series of microscope sections, discussing the behaviour of the rods and cones, the nature and functions of the visual purple, and the processes that took place in connection with the perception of light. Another interesting exhibit was a series of actual sections of different eyes mounted inside little glass capsules, which enabled the structure of the eye, the yellow spot, &c., to be very clearly seen.

Yet another striking demonstration was afforded by a series of mechanically operated slides, by the aid of which the process of accommodation and the bulging and narrowing of the eye lens due to long sight and short sight were clearly brought before the audience. In this connection the lecturer pointed out the results of the eye being non-achromatic, namely, that the eye found an exceptional difficulty in focussing blue light at a little distance, while a similar difficulty in bringing red rays to a focus was experienced in the case of very near vision. This was illustrated by the observation of a small bright spot seen through cobalt glass; with the eye a few inches away, it appeared blue with a red circumference; but at the other side of the room a red centre and a blue halo could be seen. This, the lecturer remarked, should be borne in mind in estimating the value of light of various colours for revealing detail.

Dr. Ettles next proceeded to give some illustrations of the bearing of the physiology of the eye on problems in illumination. He explained how an increase of illumination, up to a certain point, improved acuteness of vision. But a very bright light indeed reduced the ability of the eye to see fine detail, owing to the effect of glare. Glare, he suggested, might be defined as being in evidence whenever the lamp was so used as to impair acuteness of vision.

The lecturer also explained the action of the pupil aperture in closing under the influence of a strong light, but cautioned his hearers against supposing that this was the *only* cause of pupil alterations. He also showed a simple apparatus for measuring the diameter of the pupil.

In analyzing the nature of glare, as exemplified by the effect of brilliant motor-car headlights in a dark road, the lecturer explained that its confusing effect on vision was due partly to the reflection of rays to and fro by the optical surfaces within the eye, which produced a luminous haze, and therefore spoiled the definition of the retinal image. The duty of the illuminating

engineer was to see that there was sufficient light and well applied, so as to obviate as far as possible the need to wear spectacles.

In conclusion, the lecturer drew attention to the fact that illuminants contained other qualities of radiation besides the visible (heat rays and ultra-violet, &c.), but he thought further study was needed before one could form a complete and definite opinion as to their true physiological effects.

Lectures on Illuminating Engineering at Northampton Institute.

We have previously called attention to the series of ten lectures on illuminating engineering shortly to take place at the Northampton Institute. The lectures are to take place on Tuesday evenings at 7.30 P.M., commencing on Jan. 16th. The fee for the course is 10*s.* for members and 15*s.* for non-members, and for single lectures 2*s.* 6*d.*

The names of all the lecturers have now been definitely settled, and the complete course will be as follows :—

January 16th, 1912.—'The Nature of Light and of Radiation.' By S. D. Chalmers, M.A.

January 23rd, 1912.—'Photometry and the Measurement of Light.' By A. C. Jolley.

January 30th, 1912.—'The Production of Electric Light and its Distribution.' By F. M. Denton, A.C.G.I., &c.

February 6th, 1912.—Ditto. (Second lecture.)

February 13th, 1912.—'The Chemistry of Gas Manufacture and Lighting.' By S. Field, A.R.C.Sc., &c.

February 20th, 1912.—'The Use of Shades and Reflectors.' By S. D. Chalmers, M.A.

February 27th, 1912.—'Physiological Factors in Illumination.' By W. Ettles, M.D.

March 5th, 1912.—'The Practical Use of Arc Lamps.' By J. S. Plumtree.

March 12th, 1912.—'The Practical Use of Metallic Filament Glow Lamps.' By V. H. Mackinney.

March 19th, 1912.—'The Practical Use of Gas Lamps.' By F. W. Goodenough.

Royal Sanitary Institute. Examinations in Hygiene and Sanitary Science.

We have before us the syllabus and programme of the examinations conducted by the Royal Sanitary Institute in the above subjects. It is satisfactory to note that this now includes definite reference to the subject of lighting. Thus in the syllabus on 'Hygiene in its Bearing on School Life,' ventilation, heating, and lighting are treated together, and the latter subject includes : "Position and size of windows with regard to ceiling and floor. How light should fall on the occupants of a room. Artificial purposes to be considered, method, arrangement of lights, shading, pavement lights for passages, &c."

Similarly, in the syllabus referring to 'Sanitary Science as applied to Buildings and Public Works,' we find mention of the angle of daylight illumination, methods of artificial lighting, advantages and disadvantages, and size of windows.

It is satisfactory to find that the subject of lighting is now an integral part of the syllabus, and we hope that, in view of the progress now being made in this subject, even fuller attention will be given to it in future. We notice that as yet no reference is made to *methods of testing illumination*—surely an important matter for sanitary engineers to consider, and the published examination papers of last year do not appear to contain any questions on lighting.

An Indirect Gas Lighting Installation.

An interesting example of indirect lighting by gas is afforded by the newly modelled offices of the Indianapolis Gas Company, U.S.A. During a recent rearrangement of these offices it was decided to instal a gas lighting system working on the principle of reflection from the ceiling, and the results appear to have proved entirely satisfactory.

The original units employed were made up of standard available parts consisting of ordinary upright burners and mantles. Silvered glass reflectors were fixed to the burners by electric shade holders placed upside down and brazed to the outside of the Bunsen burner. But a more elegant device for carrying the reflectors has since been brought out. This consists of a spun brass holder, fitting the lower part of the burner, and having a gallery to carry the shade. This type of fitting consists in a four-light unit controlled by a chain pull, and has a pilot flame to each burner.

The scheme of decoration employed in the various offices and rooms has been worked out in harmony with this system of indirect lighting. The ceilings are of a light cream tint, and this is frequently continued to the upper part of the walls. In general the colour of walls is buff tint, but in some of the smaller offices they are finished in green.

Fig. 1 shows the effect of the installation in the general offices, which have an area of about 1,800 sq. ft., and are lighted by nine four-light fittings. The photograph was taken by artificial light.

One advantage of the indirect illumination in these offices is stated to be that the position of the individual desks at which the clerks are seated does not require to be fixed with regard to the lighting units, as an adequate general illumination is provided all over the room. It is therefore possible to make any rearrangement of the office at any time without affecting the light obtained on the individual desks. We are indebted to Mr. C. H. Graf, of the Indianapolis Gas Company, for the illustration of this interesting departure in gas lighting.

Fig. 1.—Showing indirect gas lighting installation in general offices.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

(The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.)

Notes on the Design of Motor Car Headlights.

(Proceedings at a meeting of the Illuminating Engineering Society held in the House of the Royal Society of Arts (London), on Friday, November 17th, 1911.)

THE opening meeting of the third session of the Illuminating Engineering Society was held at the House of the Royal Society of Arts on Friday, Nov. 17th, the chair being taken by Mr. F. W. Goodenough (Chairman of Council).

The minutes of the Annual General Meeting having been taken as read, the Chairman called upon the Hon. Secretary to read the names of applicants for membership received since the last meeting (see p. 682). These numbered thirty-seven in all, and in reading them out, the Hon. Secretary drew attention to the large number of members of the International Electrotechnical Commission and of the International Photometric Commission who had agreed to become corresponding members, thus greatly broadening the international and representative character of the Society. He was also pleased to announce that Prof. A. E. Kennelly, President of the American Illuminating Engineering Society, and Prof. Elihu Thomson, President of the International Electro-technical Commission, had accepted to become Vice-Presidents of the Society.

The Chairman then called upon the Hon. Secretary to present a brief report, summarizing the progress of the Society during the vacation. (This report will be found *in extenso* on p. 684.) The Chairman, in commenting on the report, remarked that the recognition of the Illuminating Engineering Society by the International Electro-technical Commission and by the Congress of Applied Electricity in Turin was a very gratifying feature, and the thanks of the Society were due to Prof. Silvanus Thompson and the indefatigable Hon. Secretary for their work in this connection.

The Chairman subsequently announced the prospective arrangements for the session, which included a paper on ' Railway Station and Goods Yard Lighting,' by Mr. Haydn T. Harrison, and a paper on ' Colour Discrimination by Artificial Light,' by Mr. T. E. Ritchie, which would be followed by a discussion on the Production of Artificial Daylight. It was proposed that other papers would be read on ' Private House and Shop Lighting,' ' The Lighting of Printing Offices,' &c., during the session, and the names of the authors of these would be announced in due course.

Dr. H. R. B. Hickman was then called upon by the Chairman to read his paper, entitled ' Notes on the Design of Motor-car Headlights,' and in the discussion which followed, the Chairman, Mr. J. E. Aston, Major Herbert, Mr. A. P. Trotter, Mr. W. F. Reid, Mr. K. Edgcumbe, Mr. L. Gaster, Mr. V. H. Mackinney, Mr. C. W. S. Crawley, and Mr. H. S. Ryland took part. After a few words of reply from the author, the Chairman formally proposed a vote of thanks to Dr. Hickman, which was carried with acclamation, and also expressed the thanks of the Society to those gentlemen who had brought exhibits to the meeting.

The next meeting was announced to take place on Tuesday, December 19th, when Mr. Haydn T. Harrison will

read a paper entitled 'Some Aspects of Railway Station and Goods Yard Illumination.'

Subsequently a number of those present availed themselves of the opportunity of inspecting the various types of headlights, &c., which were on exhibition.

NEW MEMBERS OF THE SOCIETY.

THE names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on November 17th.

Vice-Presidents—

Kennelly, Prof. Dr. A. E.	President of the American Illuminating Engineering Society, Professor of Electrical Engineering, Harvard University, CAMBRIDGE, Mass., U.S.A.
Thomson, Prof. Elihu	President of the Int. Electrotechnical Commission; President of the General Electric Co., WEST LYNN, Mass., U.S.A.

Corresponding Members—

Bast, Prof. O. de	Professor in the University of Liège; Member of Int. Electrotechnical Commission, 16, Rue César Franck, LIÈGE, Belgium.
Blondin, Prof. J.	Professor of Physics at the Collège Rollin; Tech. Editor of *La Revue Electrique*; Member of Int. Electrotechnical Commission, 171, Faubourg Poissonnière, PARIS.
Böhm, Ing. M.	Consulting Engineer to the Gasworks of Milan; Member of Int. Photometric Commission, 43, Via Vittoria, MILAN.
Boucherot, Prof. P.	Consulting Engineer; Member of Int. Electrotechnical Commission; Professor at l'École de Physique et Chimie Industrielle de la Ville de Paris, 64, Boulevard Auguste Blanqui, PARIS.
Castello, Señor A.	Engineer in the Department of Weights and Measures; Member of Int. Electrotechnical Commission, Ministero de Fomento, MEXICO.
Châtelain, Prof. de	President of the Russian Electrotechnical Committee; Professor at the Institut Polytechnique, Sosnowka, ST. PETERSBURG.
David, Ch.	Chief Engineer in the Laboratoire Central d'Electricité; Secretary of the French Electrotechnical Committee, 14, Rue de Stael, PARIS.
Eitner, Dr. O.	Professor at the Tech. Hochschule, Karlsruhe; Member of Int. Photometric Commission, KARLSRUHE, Germany.
Gariel, Prof. C. M.	Professor of Medicine; Chief Inspector of Railways and Bridges; President of the French State Committee on Illumination, 6, Rue Edouarde Detaille, PARIS.
Hahn, Prof. Dr. M.	Professor in the University of Munich, 30, Arcisstrasse, MUNICH.
Ives, Dr. H. E.	Physicist in the Laboratory of the National Electric Lamp Association, CLEVELAND, Ohio, U.S.A.
Landry, Prof. J.	Professor of Electrical Engineering at the University of Lausanne, Secretary of the Swiss Electrotechnical Committee, 57, Avenue de Rumine, LAUSANNE.
Lombardi, Prof. L.	Professor at the University of Naples; President of the Int. Electrical Congress at Turin, 1911; Member of the Int. Electrotechnical Commission, 173, S. Lucia, NAPLES.
Ott, Dr. E.	Chemist to the Zurich Gas Works; Member of Int. Photometric Commission, Schlieren, ZURICH, Switzerland.
Oya, A.	Member of Int. Electrotechnical Commission; Elec. Engineer of the Imperial Electrotechnical Laboratory, Ministry of Communications, TOKYO, Japan.
Picou, R. V.	Civil Engineer; President of the French Electrotechnical Committee, 41, Rue Saint Ferdinand, PARIS.

Rossander, C. A.	Electrical Engineer; Member of the Int. Electrotechnical Commission, Elektriska Pröfninganstalten, 38, Regeringsgatan, STOCKHOLM.
Sand, Dr. R.	Agrégé Chef des travaux anatomo-pathologiques à l'Université, 45, Rue des Minimes, BRUSSELS.
Strecker, Geh. Ober Postrat Prof. D. K.	President of the Commission of Symbols appointed by the Elektrotechnischer Verein, 106, Königgrätzerstrasse, BERLIN.
Terneden, Dr. L. J.	Member of Int. Photometric Commission; Engineer to the Corporation Gas Works, AMSTERDAM.
Verstraeten, Th.	Member of Int. Photometric Commission; President of the Compagnie Generale du Gaz, 34, Rue Marie de Burgoyne, BRUSSELS.

Members—

Allom, G.	Electrical Engineer, 15, George Street, Hanover Square, LONDON, W.
Bache, W. J.	Borough Electrical Engineer, Eythorne, All Saints' Road, CHELTENHAM.
Bush, W. E.	Lighting Dept., British Thomson-Houston Co., 77, Upper Thames Street, LONDON, E.C.
Chandler, S. B.	Distribution Dept., South Metropolitan Gas Co., 16, Tenham Avenue, Streatham Hill, LONDON, S.W.
Cortez-Leigh, F. A.	Chief Electrical Engineer, London & North-Western Railway, Euston Station, London, N.W.
Froget, A.	Engineer to Holophane, Ltd., 25, Avenue de la République, PARIS.
Grigsby, B. J.	Managing Director of Benjamin Electric, Ltd., 1A, Rosebery Avenue, London, E.C.
Head, H. C.	Engineer and General Manager, Winchester Water & Gas Co., 19, Staple Garden, WINCHESTER.
Langlands, S. B.	Chief Inspector, Glasgow Corporation Public Lighting Dept., 52, College Street, GLASGOW.
Liberty, W. J.	Public Lighting Inspector, City of London, 55, Beckwith Road, Herne Hill, LONDON, S.E.
Peronne, P. E.	Superintendent, Photometer Department, Osram Lamp Works, 12, Moore Park Road, Fulham, LONDON, S.W.
Recklinghausen, Dr. M. von.	Managing Director, Westinghouse Cooper Hewitt Co., 73, Boulevard Haussmann, PARIS.
Sainsbury, S. R.	Engineer to Holophane, Ltd., 291, Whippendell Road, WATFORD, Herts.
Scott-Snell, E.	Manufacturer of Petrol-Gas Lighting Plant, &c., Hamercot, Esher Avenue, Walton-on-Thames.

Official Notice of Next Meeting.

THE next meeting of the Illuminating Engineering Society will be held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.), at 8 P.M. on **Tuesday, December 19th,** when a paper will be read by **Mr. Haydn T. Harrison** entitled "Some Aspects of Railway Station and Goods Yard Illumination."

Members desiring to join in the discussion are invited to send in their names to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.) beforehand.

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Subsequently a number of those present availed themselves of the opportunity of inspecting the various types of headlights, &c., which were on exhibition.

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Oya, A.	Member of Int. Electrotechnical Commission; Elec. Engineer of the Imperial Electrotechnical Laboratory, Ministry of Communications, TOKYO, Japan.
Picou, R. V.	Civil Engineer; President of the French Electrotechnical Committee, 41, Rue Saint Ferdinand, PARIS.

Rossander, C. A.	Electrical Engineer; Member of the Int. Electrotechnical Commission, Elektriska Pröfninganstalten, 38, Regeringsgatan, STOCKHOLM.
Sand, Dr. R.	Agrégé Chef des travaux anatomo-pathologiques à l'Université, 45, Rue des Minimes, BRUSSELS.
Strecker, Geh. Ober Postrat Prof. D. K.	President of the Commission of Symbols appointed by the Elektrotechnischer Verein, 106, Königgrätzerstrasse, BERLIN.
Terneden, Dr. L. J.	Member of Int. Photometric Commission; Engineer to the Corporation Gas Works, AMSTERDAM.
Verstraeten, Th.	Member of Int. Photometric Commission; President of the Compagnie Generale du Gaz, 34, Rue Marie de Burgoyne, BRUSSELS.
Members—	
Allom, G.	Electrical Engineer, 15, George Street, Hanover Square, LONDON, W.
Pache, W. J.	Borough Electrical Engineer, Eythorne, All Saints' Road, CHELTENHAM.
Bush, W. E.	Lighting Dept., British Thomson-Houston Co., 77, Upper Thames Street, LONDON, E.C.
Chandler, S. B.	Distribution Dept., South Metropolitan Gas Co., 16, Tenham Avenue, Streatham Hill, LONDON, S.W.
Cortez-Leigh, F. A.	Chief Electrical Engineer, London & North-Western Railway, Euston Station, London, N.W.
Froget, A.	Engineer to Holophane, Ltd., 25, Avenue de la République, PARIS.
Grigsby, B. J.	Managing Director of Benjamin Electric, Ltd., 1A, Rosebery Avenue, London, E.C.
Head, H. C.	Engineer and General Manager, Winchester Water & Gas Co., 19, Staple Garden, WINCHESTER.
Langlands, S. B.	Chief Inspector, Glasgow Corporation Public Lighting Dept., 52, College Street, GLASGOW.
Liberty, W. J.	Public Lighting Inspector, City of London, 55, Beckwith Road, Herne Hill, LONDON, S.E.
Perorne, P. E.	Superintendent, Photometer Department, Osram Lamp Works, 12, Moore Park Road, Fulham, LONDON, S.W.
Recklinghausen, Dr. M. von.	Managing Director, Westinghouse Cooper Hewitt Co., 73, Boulevard Haussmann, PARIS.
Sainsbury, S. R.	Engineer to Holophane, Ltd., 291, Whippendell Road, WATFORD, Herts.
Scott-Snell, E.	Manufacturer of Petrol-Gas Lighting Plant, &c., Hamercot, Esher Avenue, Walton-on-Thames.

Official Notice of Next Meeting.

THE next meeting of the Illuminating Engineering Society will be held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.), at 8 P.M. on **Tuesday, December 19th,** when a paper will be read by **Mr. Haydn T. Harrison** entitled "Some Aspects of Railway Station and Goods Yard Illumination."

Members desiring to join in the discussion are invited to send in their names to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.) beforehand.

A Summary of Progress during the Vacation.

By Leon Gaster (*Hon. Secretary*).

This being the opening meeting of our third session, a few words may be said on the subject of progress during the vacation.

Committees on School and Library Lighting.

It will be recalled that after the discussions on school and library lighting last session it was decided to form two Sectional Committees dealing with these two subjects. During the vacation a number of gentlemen have been approached to act in this capacity, and the practical co-operation of the Library Association, the Association of Medical Officers in Schools, the Association of Technical Institutions, the Association of Teachers in Technical Institutions, and the London Teachers' Association has been secured. Representatives have been nominated by these Associations, and it is hoped that these Committees will act as a permanent centre of information, and that they will presently have a record of valuable work to bring before the Society.

The Constitution of these Committees is as follows :—

Committee on School Lighting.

Prof. W. C. Clinton, Mr. J. Darch, Dr. W. Ettles, Mr. F. W. Goodenough, Dr. J. Kerr, Mr. W. R. Rawlings, Mr. T. E. Ritchie, Mr. A. Stokes, Mr. S. E. Thornton, Mr. R. J. Wallis Jones, representing the Illuminating Engineering Society.

Dr. R. S. Clay, representing the Association of Technical Institutions.

Mr. P. Abbott, representing the Association of Teachers in Technical Institutions.

Mr. E. S. Mortimer, representing the London Teachers' Association.

Dr. E. H. Nash, representing the Medical Officers of Schools Association.

Committee on Library Lighting.

Dr. W. M. Bayliss, Mr. J. G. Clark, Mr. J. Eck, Mr. S. Hamp, Mr. Haydn T. Harrison, Mr. Chas. W. Hastings, Dr. H. R. B. Hickman, Mr. B. H. Jenkinson, Mr. V. H. Mackinney, Mr. N. W. Prangnell, Mr. A. P. Trotter, representing The Illuminating Engineering Society.

Mr. H. Bond, Mr. J. Duff Brown, Mr. H. Jones, Mr. R. A. Peddie, representing the Library Association.

Ex-officio on both Committees: The President, Hon. Secretary, and Assistant Secretary of the Illuminating Engineering Society.

The Standard Street Lighting Specification.

The Joint Committee, on which representatives of the Institutions of Gas and Electrical Engineers, the Association of County and Municipal Engineers, and the Illuminating Engineering Society have been nominated, are continuing their meetings, and a considerable amount of data has already been collected. It may also be mentioned that during the vacation several articles on this subject appeared in *The Illuminating Engineer*, and that the results of a series of inquiries sent to corresponding members on the Continent and in the United States were collected and presented in tabular form.*

Congress of the Royal Sanitary Institute at Belfast.

At the invitation of the Royal Sanitary Institute, the Illuminating Engineering Society nominated the President, the Hon. Secretary, Mr. J. Eck, and Mr. J. Darch to be present as delegates. The President and

* *Illum. Eng.*, Lond., vol. iv., May and July, 1911.

Mr. Eck were unavoidably prevented from being present, but the remaining two delegates did so, and a paper was presented by Mr. Darch on the subject of 'Hospital Lighting.' A paper read by Mr. W. H. Webb on this occasion contained some notes on 'School Lighting'; it was very gratifying to observe that special reference was made of the suggestions on the subject made at the meetings of this Society during the past session, and that they were recommended to school officers for special consideration.

The International Hygienic Congress at Dresden.

The International Hygienic Exhibition at Dresden was visited by Mr. J. Eck, on behalf of the Society, which was also represented locally by Prof. Dr. Ulbricht and Drs. Schanz and Stockhausen. At the suggestion of the Society some exhibits dealing with illumination were also dispatched to this exhibition, including photographs taken by artificial light showing the condition of illumination in various gas-lighted schools, by the Gas, Light & Coke Co., in various factories lighted by high-pressure gas by Messrs. Keith & Blackman, and of interiors illuminated by inverted electric arc lamps by the Union Electric Co., Ltd.

A Government Committee on the Hygienic Aspects of Lighting.

An important step has been taken by the French Government in appointing a Committee, on which prominent oculists and physiologists, engineers, and factory inspectors are represented, to inquire into the hygienic aspects of lighting.* This Committee includes within its reference the framing of standards of illumination for industrial purposes and of simple rules on illumination, the nature and causes of defects of vision and their relation to lighting conditions, the measurement of illumination, &c.

The attention of the authorities in this country has been drawn to this Committee, and the Hon. Secretary, on the occasion of his recent visit to the Continent, took the opportunity of learning the views of various influential corresponding members of the Society and Governmental Departments abroad regarding possible future legislation affecting the lighting of factories, &c. It is hoped that the precedent established by France will shortly be followed in other countries. It will be recalled that the evidence before the recent Departmental Committee on Accidents in Factories and Workshops in this country strongly emphasized the need for more definite recommendations on lighting* as a means of avoiding accidents and for the safeguarding of dangerous machinery. It was suggested that meanwhile inspectors should be given general statutory power to require adequate illumination. It is understood that the Home Office is now giving this matter very careful attention, and has arranged for tests to be made and evidence collected bearing on this point.

The Meeting of the Internatonal Electrotechnical Commission in Turin.

At the invitation of the International Electrotechnical Commission, the Hon. Secretary was present at the meeting in Turin, and a resolution was passed unanimously *that the National Committees should co-operate with the Illuminating Engineering Societies in their respective countries in studying the question of symbols, nomenclature, and other matters relating to illumination.* This resolution also received the cordial support of Dr. A. E. Kennelly and Dr. C. H. Sharp (respectively President and Past-President of the American Illuminating Engineering Society), who were present as delegates of the Electrotechnical Committee in the United States.

The International Electrical Congress in Turin.

At the International Congress of Applied Electricity in Turin, the Society was again represented by its President and Hon. Secretary. The latter read a paper dealing with 'The International Outlook in Scientific Illumination,' urg-

* *Illum. Eng.*, Lond., vol iv., Aug., 1911, p. 455.

* *Illum. Eng.*, Lond., vol. iv., April, 1911, p. 193; July, 1911, pp. 401–404.

ing that some attempt was needed to co-ordinate the efforts of the various national and international committees which dealt with illumination, so that there might be some common plan of action.

In accordance with this suggestion the following resolution was proposed and carried unanimously at the plenary general meeting on Sept. 16th :—

That this Congress deems it desirable that an International Commission should be appointed in order to study all systems of lighting and technical problems in connexion therewith ; and, having been informed that the Illuminating Engineering Society of London has the intention of forming such a Commission, and of putting itself in touch with the other existing national and international photometric committees, approves their taking the initiative in this respect.

This resolution, and also that taken at the International Electro-technical Commission, and referred to above, afford gratifying evidence of the recognition already gained by the international and impartial status of the Society, and it is hoped that the other older established societies and institutions interested in this subject will give their cordial support in forming the proposed International Commission.

It may be pointed out that the Illuminating Engineering Society is in an exceptionally fortunate position for carrying out this work, since it already includes among its members delegates on all the various national and international committees interested in illumination. During the vacation a number of distinguished representatives of the International Electrotechnical Commission and the International Photometric Commission gave their support by becoming corresponding members.

Courses of Lectures in Illuminating Engineering.

Another matter that has been decided during the vacation will also be of interest to members of the Society. The London County Council Educational Department were approached some time ago on the subject of arranging courses of lectures on illumination, and this year it was decided that the time was ripe to sanction the organization of trial courses at several institutions in different parts of London. Such courses have already been organized at three centres, the Regent Street and Battersea Polytechnics and the Northampton Institute, and the courses at the two first-named institutions have already commenced.

These lectures are intended as a preliminary to more complete courses in the future, but a new precedent has been set in the organization of a course in which the various sections of the subjects, gas and electric lighting, photometry, &c., are dealt with by lecturers who have made a special study of their respective departments. It is hoped that these courses will receive cordial support from members of the Society, as they afford an opportunity of dealing with certain sections in a more complete manner than is possible at the ordinary meetings of the Society.

In conclusion, the Society may congratulate itself on having substantially increased its membership and influence during the vacation. An interesting series of papers has been arranged. It is hoped that members will continue to give their active support in making the aims of the Society known, so that it may reap the benefit of this preparatory work during the coming session.

Indirect Lighting by Arc Lamps.

We are informed that a paper on the above subject will be read by Mr. J. Eck at a meeting of the Electrical Contractor's Association at the House of the Institute of Sanitary Engineers (120, Victoria Street, London, S.W.) at 8 p.m. on December 6th, 1911. This paper will doubtless be interesting to many members of the Illuminating Engineering Society

Notes on the Design of Motor Car Headlights.

By H. R. B. Hickman, M.A., M.B., M.R.C.S., L.R.C.P.

(Paper read at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London), on Friday, November 17th, 1911, at 8 P.M.)

The subject chosen for this paper is one in which I have taken considerable interest, especially from the point of view of the causes and suppression of glare and dazzle. With the exception of the Royal Automobile Club's Test of Headlights at the Crystal Palace, in July, 1909, nothing definite has been done, nor has the matter of prevention of glare been formally discussed by experts in Illumination, such as may be found in the membership of this Society; and it is mainly with a view to promoting such a discussion that I venture to bring this paper before you.

The requirements of an ideal Motor Headlight may be discovered by looking at it from two points of view :—

(1) that of the driver of a car;

(2) that of the other users of the road.

(1) In investigating this matter from the point of view of the driver of a car, let us take an imaginary drive on a dark night along a country road behind a powerful headlight of the searchlight type.

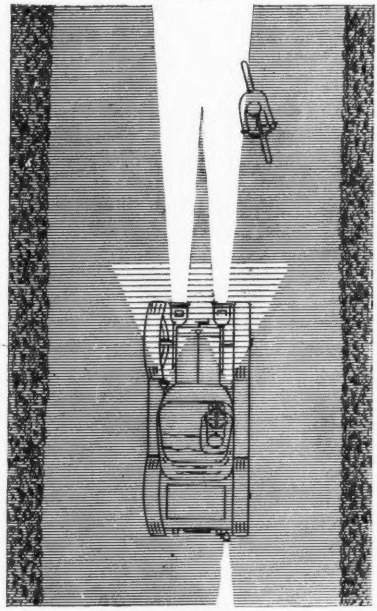


FIG. 1.—Bird's-eye view of car; cyclist emerging from light into dark space.

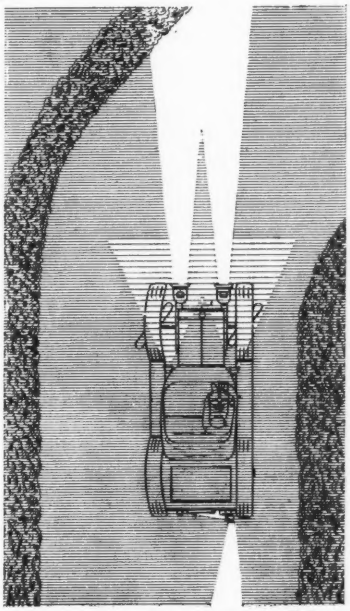


FIG. 2.—Car turning corner; inefficiency of fixed headlights.

One point is immediately noticeable, that objects not illuminated by the lamp are less visible than they previously appeared to be, and that the night around, and especially behind, appears to be darker. The presence of glare is seen at the very outset, and is evident all through. The definition of glare that best applies in this connection is as follows: "Glare occurs when the intensity of illumination of objects

whose images fall peripherally on the retina is relatively great compared with that of the object whose image is at that moment centred on the yellow spot."

As the car goes along, pedestrians can be distinguished 100 ft. or more ahead, but as the car approaches them they reach a narrower portion of the beam (Fig. 1) and emerge from the area illuminated into a much darker space only feebly, if at all, illuminated by the side lamps, and here it is possible they may be lost to view in the semi-darkness and perhaps struck by a mudguard in passing without any one on the car being aware of it. Accidents of this nature have happened and persons have been injured and left lying on the road quite unknown to the driver. Owing to the narrowness of the beam cross-roads cannot be seen soon enough to slow down and get the car in hand for possible cross-traffic which the existence of high hedges probably also hides.

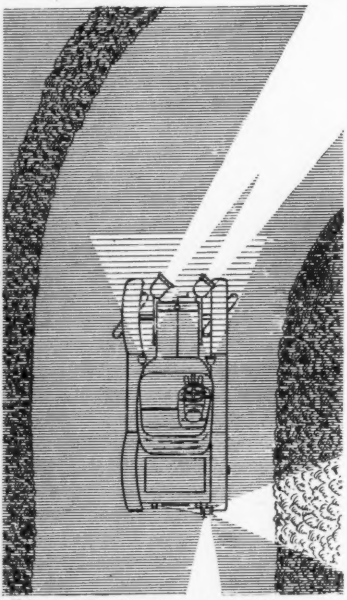


FIG. 3.—The advantage of swivelling lights when turning corners.

If it is intended to turn the corner, owing to the fixed position of the lamp it is possible to run into the hedge or ditch on the inner side, since, until the body of the car has swung round sufficiently, the full width of the road is not illuminated (Fig. 2). One of the curious illusions when driving at night is that of continually being on the approach to a blind corner where the road seems to end abruptly; this "corner" merely being the farthest point ahead that can be seen.

(2) From the pedestrian's or cyclist's point of view, picture what happens when a car is coming round a corner on to a straight stretch of road where the pedestrian is walking. As the car approaches, above the tops of the hedges and even as high as the branches of the trees, can be seen the glare of the oncoming lamp; as it nears the corner the beam is concentrated in a gradually decreasing circle of light on the hedge at the outside of the bend (Fig. 2), and when the car quickly swings round the corner, the light suddenly streams down the straight, enveloping the victim in a blinding dazzle in the shape of a ball of fire which is apparently turned on him wherever he moves to avoid it. If he, as is usual, shrinks from it to the side of the road, it is not until the car is some 30 ft. or so from him that he can escape the spread of the beam, only then to be left in such darkness that unless the diffused unreflected light from the naked burner spreads far enough laterally, or the side lights are sufficiently powerful, he is nearly invisible to the driver, while still blinded from the previous dazzle. Finally, as the car passes he is plunged into a "darkness that can be felt," where he is unable to see either his way or whether there is some other vehicle almost on the top of him.

This "dazzle" occurs when light enters the eye directly from the source of illumination, and if the intrinsic brilliancy of this is not greater than that of an ordinary acetylene flame, the naturally divergent rays of which are not parallelized more or less by any lens or reflector (*i.e.*, it is a naked flame), then the dazzle is not so harmful.

It is clear, then, that a brilliant light of long range is an absolute necessity for the safety both of the car and the pedestrian; but that modifications are

required in the character of the beam to render the illumination produced acceptable equally to the motor driver and road users.

Conditions to be complied with by an Ideal Headlight.

From what has been described, the following should be the properties of an ideal headlight :—

(1) The road should be well illuminated over such a distance that time is given to stop before the car reaches an obstacle.

(2) This illumination should extend to the sides of the road near the car as well as far ahead ; whether by means of the main beam or independently, in order to avoid dark areas near the car.

(3) The lights should indicate clearly the extreme width of the car as well as its position.

(4) The space for a few yards behind the car should be illuminated, but not too brilliantly.

(5) No part of the main beam should exceed a height of 4 ft. 6 ins.

(6) The headlights should turn with the steering wheels (Fig. 3) ; or, until the curious regulation forbidding swivelling headlights is abolished, a sufficiently divergent beam should be used to enable corners to be taken with safety.

(7) The apparatus should be light and not liable to get out of order, and should not require any mechanical devices to take the attention of the driver.

(8) Good penetrative power is required in foggy weather.

The first condition is best fulfilled by the use of a central projector designed to produce a beam whose range is found as follows :—With an average car doing 20 to 24 m.p.h., it is possible to stop in, say, 35 ft. ; at least one second must be allowed for indecision in applying the brake, and this, at 20 m.p.h., means 30 ft. ; another 30 ft. must be allowed for the velocity of approach of the oncoming vehicle which it is required to avoid ; there is, then, a total distance of 90 ft., which should be the minimum range of the lamp.

Allowing for a road width of 36 ft., the divergence of the beam should be, roughly, 24 degs. ; assuming a car width of 5 ft., this means that the beam is narrower than the car for a distance of 13 ft. The dark margins over this 13 ft. must be illuminated by the use of side lamps providing wide beams. These side lights should be mounted well over the mudguards to indicate the width of the car.

The tail light should be arranged to give a little general illumination on the off-side (Fig. 3), so as to soften the abrupt change from the brilliant light in front of the car to the darkness behind ; this light, shining on the hedge, also

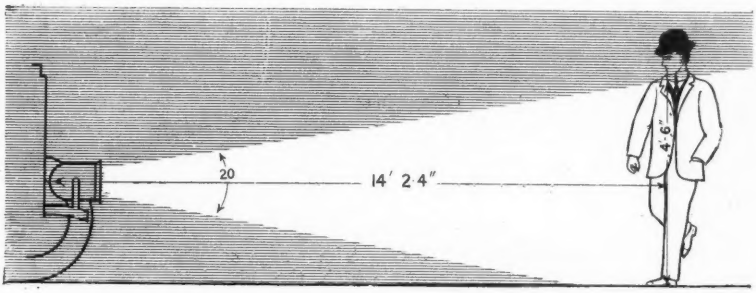


Fig. 4.—Showing the short distance within which there is no 'dazzle.'

forms a useful tell-tale to the driver, indicating the condition of the light.

Special devices are necessary to prevent the dazzling effects of the headlights on others on the road; this dazzle appears to be due (as mentioned above) mostly to the direct reflected beam, and but very little to the unreflected light from the front of the naked flame. There are several ways of overcoming this, which will be described later.

There are other difficulties which can only be met by compromise; for instance, experience shows us that however long or short the distance illuminated may be, all beyond the limit of the illuminated area appears by contrast darker than before; and that in order to *see* far ahead there must be as little light as possible close at hand.

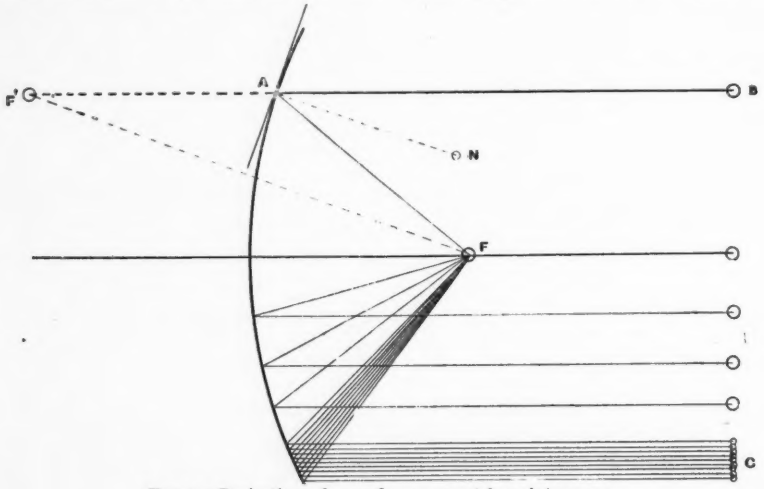


FIG. 5.—Projection of rays from geometric point source.

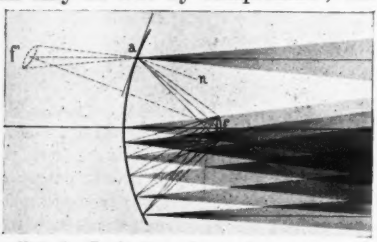


FIG. 6.—Projection of rays from a flame of ordinary size

Before referring to the optical principles, a short résumé of the R.A.C. Headlight Tests of 1909 may be of interest. The principal measurements made were of the range of the projected beam, its horizontal dispersion, and dazzling effect.

The range was found at which the lamps would give an illumination of 1/10 candle-foot; the average (of thirty-three lamps) was found to be 90 ft.; the average height of the lamps from the ground being 2 ft. 7 ins.

The horizontal dispersion, over which the illumination was not less than the above standard, was measured at half the range at the heights of 3 ft. and 4 ft. 6 in. from the ground. The average angle of divergence was 20 degs.

The dazzling effect was estimated by observing the distance in front of the lamp at which an object 6 ft. to the side and 6 ft. behind the lamp could be distinguished. The test object was such as could be seen at a distance of 100 ft. on a clear dark night in the absence of any headlight. The results of this test were very variable, and the range extended from 5 to 41 ft. (av. 22). The candle-power of the acetylene burners was also taken and found to range from 15 to 25 c.-p., showing how erroneous was the commonly accepted estimate of about 100 c.-p. The elec-

tric filament lamps gave from 3·9 to 76 c.-p.

One very important point seems to have been overlooked, and that was the height of the beam above road level. The standard candle-power at half range for the width of the beam at a height of 4 ft. 6 in.—"eye level"—was measured as stated, but no account was taken of how much higher the light extended further away; it can be easily seen (Fig. 4) that if the average divergence was only 20 degs., the rays would extend above the eye level from a point as near as 14 ft. 3 in. from the car, and the dazzle would be a maximum.

The lamps that were most free from the dazzling effect were those consisting of a lens mirror system alone; any additions such as parabolic hoods or front lenses appeared to increase the dazzle.

Optical Principles.

The Source of Light.—The smaller the source of light, and the greater its intrinsic brilliancy for a given total candle-power, the more perfect the effects produced.

In the particulars of lamps one often sees wonderful diagrams of the sort of beams they are supposed to project; the source of light shown is the theoretical point source, and the result a shaft of accurately parallel rays. The fallacy that any source of illumination yet invented can produce results even approaching these in perfection is continually repeated. There is a reasonable excuse, therefore, in bringing before you two diagrams of the most elementary character, in order to compare the effect of using a flame of finite dimensions with that of the mere point; for they appear to show the essential features more clearly than any more elaborate construction would do.

Taking, first (Fig. 5), an imaginary point of light at the focus of a parabolic reflector of large aperture; the latter may be considered to be composed of innumerable minute plane mirrors each set at a tangent to the curve: one of these (much exaggerated) at (A), of which (N) is the normal; a point source at the focus (F) will be reflected according to the law, and an image of it reflected parallel to the axis of the mirror, and as if it came from (F′) behind the reflector. Similarly, from every point of the mirror will be reflected an image of the source, resulting in a parallel beam composed of innumerable images of the light source in contact with each other, forming one "amorphous" disc of light (if such an expression may be used) of the same diameter as the reflector. So much for the theoretical point source.

If, now, the illuminant be such as is commonly used, say, acetylene, there is a flame of finite dimensions, and the results are very different. The size of the flame being very large in comparison with the minute portion of the mirror considered in the previous

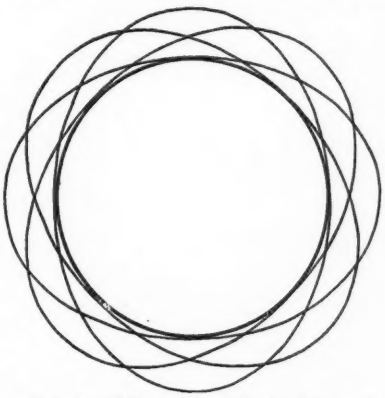


Fig. 7.—Halo round projected beam of fig. 6.

case, the rays proceeding from this flame to the mirror will be convergent. On making a diagram (Fig. 6) of the paths of the reflected rays, it is found that the resultant beam is composed of a number of cones with their apices at the surface of the reflector and their bases, which (except that proceeding from the pole) are elliptical, overlapping as they proceed away from the mirror; a larger number overlap in the centre of the beam than at the periphery, consequently the resultant divergent beam is brighter at the centre, and surrounded by a narrow margin, or halo (Fig. 7), of diminished intensity.

The angle of that cone which is subtended by the flame at the pole is the

greatest, and determines the maximum divergence of the main beam. For instance, with a flame $\frac{3}{4}$ in. in diameter

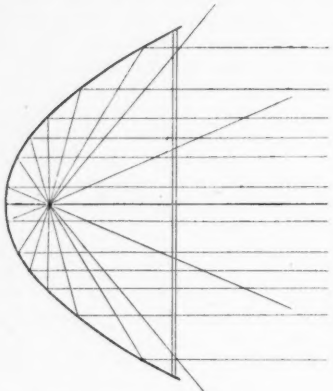


FIG. 8a.—Parabolic Bell Reflector.

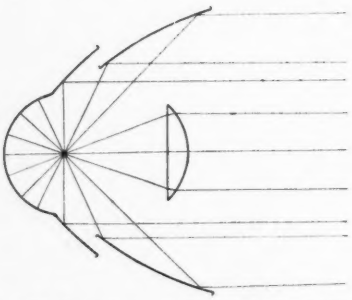


FIG. 8b.—Sphero-parabolic Reflector with condensing lens.

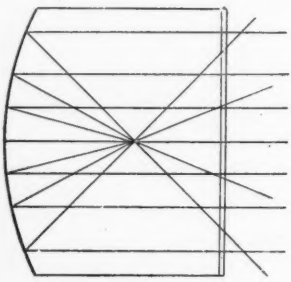


FIG. 8c.—Parabolic Reflector.

at a focal distance of 3 in., the angle of the central cone is 15 degs., and this at 90 ft. would give a disc of light $23\frac{1}{2}$ ft. in diameter.

Consideration of Fig. 6 will supply the following information:

(1) If the *size* of the *flame* be increased, the angle of the cones will be also increased, and the *area* of illumination will be larger, but the intensity of illumination is *not* affected.

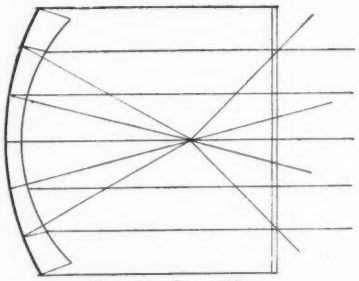


FIG. 8d.—Lens Mirror.

(2) Any increase in the *focal length* of the reflector will diminish the number of elementary cones, and therefore the intensity of illumination; but the angle also of each of the cones will be diminished, tending to increase the illumination; and

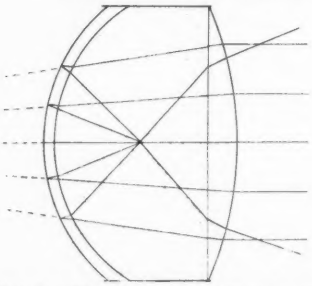


FIG. 8e.—Hyperbolic Reflector with front plano-convex lens.

these two conditions balance, but the *area* illuminated will consequently be smaller and the halo less, while the intensity is unaffected.

(3) Increase in the *diameter* of the reflector will increase the *number* of cones reflected, and therefore the *intensity* of illumination, in proportion to the area of the aperture, or square of its diameter; but the halo will also be greater.

Increase, therefore, in the diameter of the reflector with, at the same time, a proportionate increase in its focal length, will increase the intensity of illumination and reduce the area illuminated, but the halo will be less.

Hence :—

Intensity of illumination (number of cones) is determined by the intrinsic brilliancy of the flame and diameter of the reflector.

Area of illumination (angle of cones) depends inversely on the focal length of the reflector and directly on the area of the flame.

Since alteration in the size of the source of light does not affect the intensity of illumination, but only the total candle-power, a smaller flame of great intensity is an advantage, for it can be used in a smaller lamp, and there will be less aberration ; the area illuminated, however, also depends partly on the size of the flame, and must therefore be taken into account.

Next, the diameter of the reflector should be as large as convenient, remembering that increase in illumination is proportional to the square of the diameter.

Finally, the focal length must be short so long as the halo is not unduly large or the flame too near to the reflector to be safe. The larger the source of light, the longer the focal length should be, in order to diminish aberration effects. Here the electric filament lamp has the advantage, for its heat is not great, while its intrinsic brilliancy is very considerable, and it can be placed close to the reflector ; but a really good compact focus type filament is wanted.

Type of Projector.—There are two classes into which all systems of projection may be divided :—

(1) Those consisting of a reflector behind the source of light, with only a plane glass in front. The reflector being of a parabolic, parabolic bell, or mangin (lens) mirror type. (Figs. 8a, 8c, 8d.)

(2) A reflector (spherical, parabolic, or hyperbolic) in combination with a front lens. (Figs. 8b, 8e.)

To either of these classes certain refinements may be added. These are shown in the diagram with the theoretical point source and parallel beam ; the actual results in practice with a flame of ordinary size would be very different, and in the figures 9, 10, and 11, following

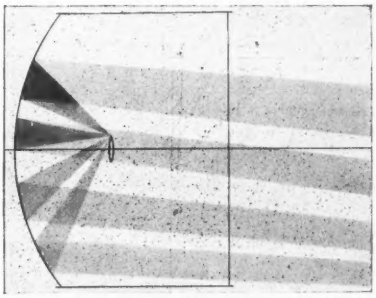


FIG. 9.—Direction and form of pencils reflected from parabolic reflector ; those proceeding from the top of the flame only are shown.

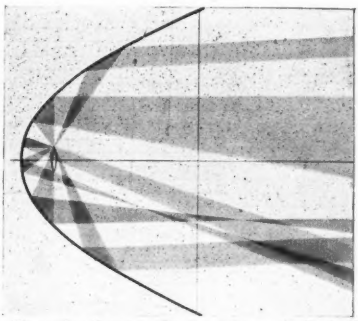


FIG. 10.—Same as fig. 9, with parabolic bell reflector.

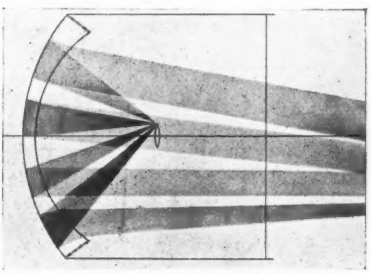


FIG. 11.—Same as fig. 9, with lens mirror.

the direction of the rays from one extremity only of the flame are shown. It will be seen at once that the rays, as a whole, diverge, and also that some

form parallel, others divergent, and even convergent pencils intersecting at various points, producing areas of unequal illumination, which are most marked in the parabolic bell reflector (Fig. 10) in which the light of maximum intensity forms a hollow cone, which is projected as a line across the road, and therefore useless to drive by. It will be observed that if the focal length were somewhat increased, these erratic pencils would be less marked. Moving the light to one or the other side of the focus would only render the beam more divergent, or else convergent to a certain point, and then divergent.

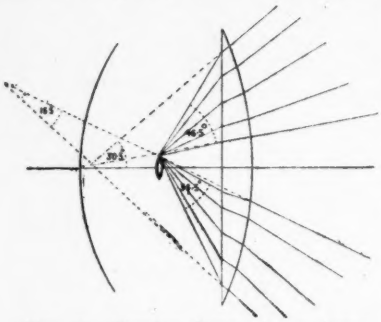


FIG. 12.—Showing divergent rays from front of burner parallelised at margins of lens.

In order to obtain a given divergence of beam, both the diameter of the flame and the focal length of the mirror must be taken into account. With a given flame the ratio of half the diameter of the flame to the focal length is equal to the tangent of half the angle of divergence. Thus, a flame 2 cm. wide will

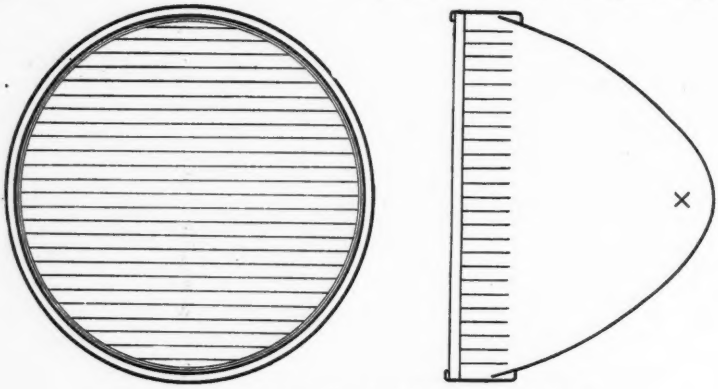


FIG. 13a.—Louvres preventing dazzle of divergence of beam.

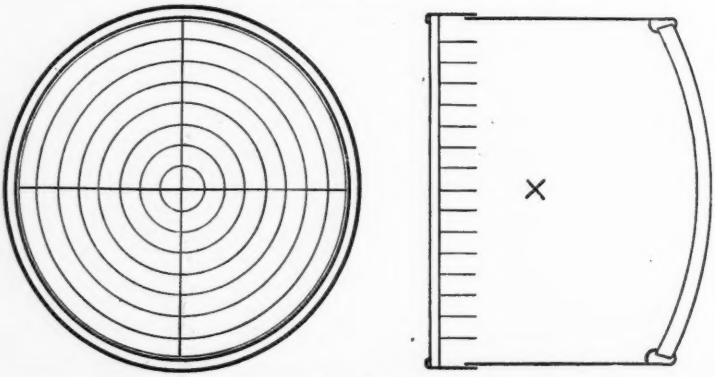


FIG. 13b.—Louvres preventing dazzle of divergence of beam.

give a divergence of 20 degs. at a focal distance of 5·67 cm.

Special Devices for preventing Glare and Dazzle.

In the type of lamp in which there is no front lens the rays from the naked flame diverge in all directions without any tendency for the cones (referred to in Fig. 9) to overlap and produce areas of increased intensity of illumination; so that if the intrinsic brilliancy of the flame is not very great, there is comparative freedom from dazzle. In the case of the system of reflector combined with front lens these rays are somewhat parallelized (Fig. 12); in fact, owing to the spherical aberration of the lens margins, the pencils there are rendered quite parallel, and consequently the dazzle from the front of the flame is greater near the lamp than further away.

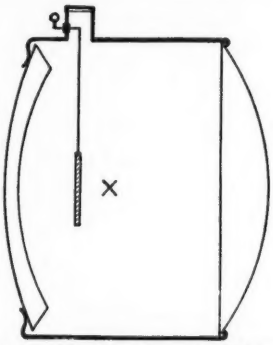


Fig. 14.—Movable obscurator behind the flame cutting out reflected main beam.

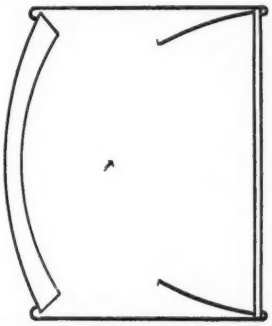


Fig. 15.—Parabolic front ring reflector to parallelise divergent rays.

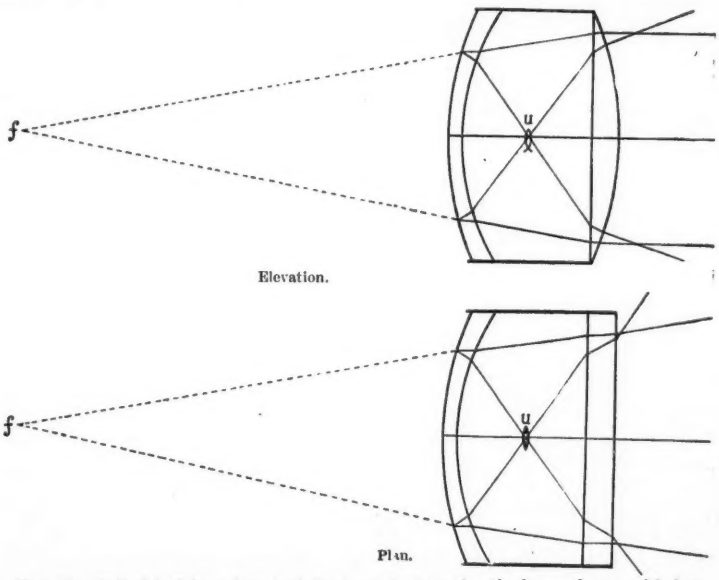


Fig. 16.—Cylindrical front lens (axis horizontal) flattening the beam above and below.

Two devices to prevent this dazzle have been used; one, consisting of an opaque disc, or small lens mirror, in *front* of the flame; the other, a funnel-shaped reflector with or without a con-

densing lens which will bring the divergent rays into the form of a parallel beam. It seems, however, a mistake thus to do away entirely with the useful diffused light near the car.

Since, as has been shown, the main beam is necessarily a divergent one, at a certain distance from the car it will blaze into the eyes of any one standing in front, and this form of dazzle is the most objectionable. (*Vide* Fig. 4.) Several methods of obviating this are in use :—

(1) Louvres, parallel or concentric, made of metal or glass, and either fixed or movable at the will of the driver (Figs. 13a. 13b).
(2) Obscurators behind the flame, extinguishing the main beam (Fig. 14).
(3) Ring-shaped parabolic reflectors in the front of the lamp (Fig. 15).
(4) Cylindrical front lenses, axes horizontal (Fig. 16).
(5) Prisms, base down, in place of the plane front glass (Fig. 17).

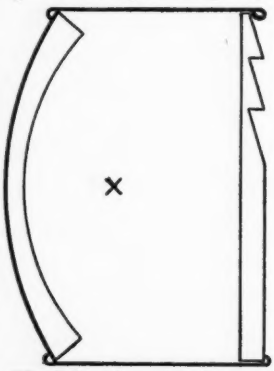


FIG. 17.—Prisms formed in the front glass flattening the top of the beam.

At the outset it seems that mechanical devices should be ruled out ; for, before they can be operated, the approaching cyclist, for example, has first to be seen (and therefore dazzled) by means of the long, intense beam ; then the driver, whose attention is fully occupied, has to remember to operate the eclipsing mechanism (Fig. 14) ; if he does, the sudden change from glaring brilliance to comparative and unexpected darkness is a source of greater danger to the cyclist than the previous glare.

Louvres.—These consist of thin strips of metal arranged in either concentric circles behind the front glass, or horizontally, like a venetian blind. In some cases the latter are movable. These strips are dead-black on the upper surface and plated on under side, or they may be formed of horizontal strips of glass ground on the edges and cemented together to form the front glass.

The former horizontal type (Fig. 13a) reflects down the upward diverging rays and absorbs those having a downward direction ; the latter would tend to absorb both. The concentric form (Fig. 13b) has the disadvantage of preventing any lateral spreading of the beam.

Unfortunately, both do away with all the useful diffused rays from the naked flame.

Ring - shaped parabolic reflectors (Fig. 15) suffer from the same disadvantages as parabolic reflectors elsewhere, and with a large source of light would give erratic divergent pencils.

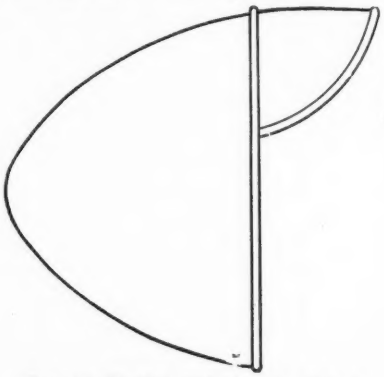


FIG. 18.—Hooded extension of body of lamp directing downwards some of the divergent rays.

Extensions of the lamp body in the form of hoods (Fig. 18) only partly control the upwardly divergent rays ; their effect at a little distance from the lamp is nil.

Cylindrical Front Lenses.—A lens of this shape, with its axis horizontal in combination with a hyperbolic mirror (whose virtual focus is the principal focus of the lens) is an idea that was patented by me some time back (Fig. 16) ; it is designed to render the upper diverging rays approximately parallel with

the road and below the line of sight, while allowing the beam to spread laterally.

Prisms.—These are similar in action to the cylindrical lens, except that they form the upper part only of the front glass out of which they are ground (Fig. 17). They are used in combination with a lens mirror giving parallel rays, and their action is merely to bend down the upper rays.

In order to obtain a wider beam than a lens mirror of the ordinary type produces, cylindrical strips are sometimes fitted with their axes vertical (as used in lighthouses), in place of the front glass. Another method is that used in the Army for projecting a wide beam through an embrasure under cover, and consists in forming the reflector with a curvature parabolic in vertical section and elliptical in horizontal section; this, of course, gives rise to a parallel beam in vertical section, but rapidly convergent horizontally to the conjugate focus of the ellipse, afterwards diverging widely.

A reflector of this type was made for me, but differing in this respect; the horizontal section was spherical, while the vertical was parabolic, as above. The form taken by the reflector being that of half a barrel. The light was placed at the centre of curvature of the spherical section, which was at the same time the focus of the parabola; the shape of the beam was elliptical, long axis horizontal.

It is easily seen that if the source of light could be made wide, but of small depth, many of the upward diverging rays could be eliminated, while securing a useful diverging beam. There is an ingenious method of producing a wide flame without increasing its height. The flame is placed to one side of the centre of curvature of a spherical mirror (Fig. 19), consequently an image of it is formed (inverted) beside the flame itself, which is at the focus of a plano-convex lens, thus doubling the apparent size of the flame.

Finally, the difficulty in penetrating fog has to be considered. It has been found that yellow light can be transmitted through fog more easily than white light; therefore, yellow screens and gilded reflectors have been recently used. This does not appear to be a new idea, for there is an account of the greater penetration of the light from a brass reflector in heavy weather in some lighthouse tests about sixty years ago.

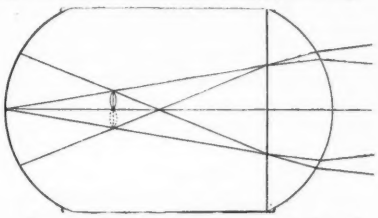


FIG. 19.—Duplication of apparent size of flame at centre of spherical reflector.

A considerable part of the difficulty in penetrating fog is due to the position of the lamp, the upper diverging rays from which are usually at such an

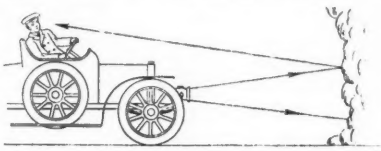


FIG. 20.—Reflection of light back from fog bank.

angle that they are reflected back from the fog bank into the eyes of the driver (Fig. 20). The obvious cure is to arrange the lamp, or lamps, to slightly converge their beams, so that the reflected rays are returned towards the sides instead of directly back on the car (Fig. 21).

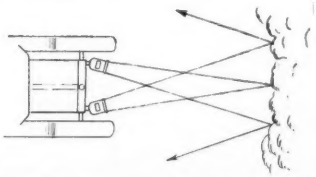


FIG. 21.—Lamps (seen from above) with their axes slightly convergent so that the rays reflected from the fog are directed to one side.

In conclusion, though I may not have brought forward any new points or inventions, I hope to have called attention to some of the defects in Motor car Headlights, and the paper will have achieved its object if it calls forth a lively discussion, in which there may be views advanced totally at variance with those given by me.

Discussion.

THE CHAIRMAN, after expressing the thanks of the meeting to the author for his paper, said he was not going to attempt to discuss the technical part of it, because he was not qualified to do so. He could only say as a motorist that Dr. Hickman had set out very correctly the problem that had to be solved, and if he succeeded in getting the manufacturers of lamps to realize his problems and to solve them by the aid of the information that he had given in the paper, he would have done a good service. After jocularly referring to the fact that Dr. Hickman had shown in all his diagrams cars being driven on the wrong side of the road, the Chairman said it was a most important point that the lighting of motor-cars should indicate clearly the extreme width of the car as well as its position. His own car had very wide wings on the mudguards, and it was difficult when driving to remember really what the width of the car was. Consequently, he was quite sure that any one approaching or cycling towards the car, and being dazzled by the lamps, would be almost sure to misjudge the width of the car, because at night they would not know whether it was a big cabriolet body car, as his own was, or a narrow-body touring car, and something that would indicate exactly the width would undoubtedly be a decided advantage to the pedestrian. The point raised by the author as to the tail light showing on the hedge as well as the number-plate was also a decidedly practical point, because, as he could speak from experience, it was impossible for the driver, with a lamp that did not do this, to know whether it was alight or not. In towns they could judge by the reflection in a shop window.

MR. J. E. ASTON said that no matter how good a tail light they might have, the light was very often prevented from showing on the hedge by the position in which the lamp was placed on the car. He also referred to the point dealt with by Dr. Hickman with regard to parabolic reflectors with front lens mirrors. He could not quite understand how, if the light was reflected down, the beams could cross as long as the planes were parallel. He would like the lecturer to explain that, if possible.

MAJOR HERBERT described a form of appliance which he had patented for causing head lamps on a motor car to swivel in connection with the steering gear. Owing to the size of the apparatus, he had been unable to bring it to the meeting, but he explained it as follows by the aid of a sketch. The mechanism is the same as that for turning the steering wheels; the two brackets for the lamps turn in bearings, and have attached at their bases two small bell cranks connected at their ends by a rod, so that the two must move together in the same way that the two steering wheels of the car move together. Attached to the lower end of the shaft of the off-side lamp bracket is a short arm, and this is connected by a rod to the steering arm which projects below the chassis of the car. The result was that, as the car was steered normally, the lamps and steering wheels turned together. He had had this arrangement fixed on three cars since 1906, and during the five years' fairly hard work he had never had any trouble with it. He believed it was the general opinion that swivelling lamps were prohibited by the Local Government Board, but he had endeavoured to get himself "run in" for using them, and had failed. The Legal Committee of the Royal Automobile Club went into this matter and pronounced swivelling lamps legal—or, at any rate, not contrary to regulations, and the Club had followed up this decision, he believed, by an offer to defend any member who might be

prosecuted for using such lamps. In Article II., Condition 7, of the 1903 Regulations of the Local Government Board there were two paragraphs. The first one stated how lamps were to be placed on the car, and the second one stated that these lamps must be so constructed, fitted, and attached as to prevent the movement or the use as a searchlight of the light, &c. There is a proviso exempting bicycles and tricycles from the operation of the first paragraph, but they are not exempted from the second paragraph. As a matter of fact, the headlight of a motor bicycle being fitted to the steering head was in effect a swivelling headlight of the kind which was thought by many to be illegal for motor-cars, and yet the law was the same for motor cycles and motor-cars. It would be a very unusual thing for any motor cyclist to fix a lamp to his motor cycle which would not turn when the front wheel turned.

Mr. A. P. Trotter said he was quite unable to say anything about motor-cars except as a pedestrian, to whom they were an unmitigated nuisance, but he would be delighted to see this subject thrashed out. He had looked at the report of the trials carried out at the Crystal Palace by the Royal Automobile Club some time ago. This began by suggesting that they were going to discuss the question of glare, but apparently they were so interested in the other experiments that they forgot to go on with it, and as far as he could see there was little in the Report about glare, which was one of the most important subjects affecting pedestrians. As, however, motor-car headlights worried the drivers themselves almost as much as they worried pedestrians, there was a hope that something might be done. The diagrams in the paper showed how carefully the author had gone into questions which were overlooked in ordinary text-books on optics, as to the size of flames and consequent divergence of a beam. The author made one or two suggestions of canting part or whole of the beam. At first sight it appeared that if the beam were thrown down a little and brought out of the eyes of the people using the road, it would show the road, at all events, to the driver; but that would only be so if the road were dead-level. But the beam must of necessity rise and fall with the undulations of the road, and so it did not seem to be possible always to keep the beam down. Further, if they did try to keep it down, the angle would be very small—not more than about two degrees; otherwise, they would not reach the distant point on the road. The author stated: "Glare occurs when the intensity of illumination of objects whose images fall peripherally on the retina is relatively great compared with that of the object whose image is at that moment centred on the yellow spot." The Illuminating Engineering Society had devoted two evenings to discussing glare. The word might be used in two ways. A lamp is said to glare when its brightness is relatively great compared with the background against which it is seen. A lamp having a black curtain behind it would have more glare than the same lamp with a white wall behind it, although more light would be received by the eye in the latter case than in the former. The author used the word "glare" in a different sense. He assumed that the lamp is not being looked at, but some object on one side of the lamp. It is somewhat unfortunate that the word "glare" should be used in these two ways, for the definitions are exactly opposite; but when it is understood that the words "objects whose images" in the author's definition refer to a lamp or lamps, or other sources of light, and "the object" to something by the side of the lamp, it is quite correct. When they discussed glare they came to something a little bit outside the realm of physics. Physics was the only science that had decent units, and a physicist always felt at sea if he meddled with such subjects as physiology. Glare was the first thing to be avoided, and after that the question of the divergence of the light, the amount of lighting, hedges, and all these things were matters which the motor driver himself must settle, and undoubtedly they could be settled.

MR. WALTER F. REID spoke with regard to fog and mist. He had had, he said, some experience of that in connection with balloons. He had taken photographs from a balloon which were so fogged that they could not clearly see things that were photographed. At the same time a friend of his happened to be photographing him, and the photograph of the balloon was quite clear and distinct. This, he thought, was because the rays of the sun were reflected back from the particles of fog and mist in the air, which, whilst they completely fogged *his* plate, did not affect the other camera down below. He thought this to some extent corroborated what Dr. Hickman said—that the lightning, when there is a mist or fog about, should, if possible, be oblique. Of course, there was not a very long base line to a car ; but, as was seen in Fig. 21 in the paper, it was quite possible to do it. The source of light, he thought, was really the most important part of the whole subject. If they could have a single luminous spot of light, the optical efficiency would undoubtedly be better. They could deal with the rays in a much better way than with a large illuminated area, such as the wires of an electric lamp. It seemed to him that this was a point which was even more important than the optical divergence of the rays. He thought the best source of light was acetylene. He had made a study of illumination by acetylene, one of the results of which was that the London General Omnibus Co. were now introducing a new method of acetylene lighting, which depended more upon the generation of pure acetylene in the vehicle than the burner or anything of that kind. There were some excellent acetylene burners now on the market, and in spite of the fact that electric lamps were giving very great satisfaction, he thought that great stress should be laid upon the concentration of the source of light as obtained in acetylene burners.

MR. K. EDGCUMBE asked whether the author had actually tried the effect of crossing the headlight beams in a fog. He would hardly have thought that the reflection from a bank of fog would be like the reflection from a mirror, but rather like that from a matt surface, and that it would consequently be almost immaterial at what angle the rays of light struck the bank, as they would diffuse in all directions. Therefore, he did not think the crossing of beams would be altogether a solution. Perhaps, however, the author could give some information upon this subject.

THE CHAIRMAN remarked that if they were going to turn their lamps inwards to any material extent, they were going to increase the danger of having darkness near the car, because this would destroy the tendency of the light to diffuse towards the hedge on the other side. Any marked turning inwards of the lamps would be a serious drawback from the driver's point of view. Had Dr. Hickman experimented in this direction ?

MR. L. GASTER said he would like to say a word or two on Dr. Hickman's interesting paper. He was very glad to see the general recognition of the need to avoid "glare" in connection with headlights, and was sure that they would all feel the importance of this point in connection with traffic regulation.

A short time ago the Society had held a discussion on this subject of glare, and they took the opportunity of drawing the attention of the City and Metropolitan traffic officials to the subject. It occurred to him that it would be interesting to do the same in connection with this discussion, and by the kindness of the authorities at Scotland Yard he had received some copies of the regulation regarding motor vehicles. It was very satisfactory to see that the question of lighting and dazzling effects was appreciated. In the Regulation of March 14th, 1910, affecting motor-cabs, it is provided—"head lights of great brilliancy or likely to have a dazzling effect will not be permitted." In the Notice to proprietors of motor omnibuses (August 30th, 1909) it is also stated that "headlights of great brilliancy will not be permitted," and,

further, that the "carriage must be suitably lighted inside and outside."

The intention of these rules was excellent, and no doubt the authorities had done all in their power to safeguard the interests of the public in this respect; but he would venture to suggest that it would be advisable to make clearer the qualifications required. How was the applicant to know what was meant by "sufficiently lighted," and what constitutes a dazzling headlight?

He felt that the time was ripe for an attempt to prescribe more definitely on these points, and it should not be impossible to frame some tests, based on photometric measurement, of the diminution in acuteness of vision under certain conditions which would act as a guide to those interested in these matters.

He thought this was a question with which their Society might occupy itself, and it might also be commended to the Royal Automobile Club, which carried out a series of tests on headlights in 1909. In considering the dazzling effect of headlights one must not only consider their effect at a certain distance, but also the after-effect on the eyes after a brilliantly lighted car had passed by and left the road in comparative darkness.

As an illustration of the principle that more brilliant headlights were not necessarily a convenience to drivers, he would refer to some tests carried out by C. F. Harding and A. N. Topping in the State of Indiana, U.S.A. The Indiana Railroad Commission had at that time been asked to report upon the desirability of increasing the power of headlights on locomotives, and arranged for a series of tests to be carried out at the Purdue University and also on the railways in actual operation.*

He thought that a perusal of these tests might yield some interesting information to motorists, and he would also like to draw their attention to the discussion of the Illuminating Engineering Society in 1909 on 'Glare.'

In conclusion, he hoped that the meeting might be the means of conducing those concerned with motor-car headlights to study the effect of these lights on the eye more closely, and to endeavour to settle upon more definite rules, by which it could be decided whether a given light came within the definition of glare or no. The question was one of considerable interest both to lighting experts and the motoring industry, and he thought they might well co-operate in investigating these matters.

Mr. V. H. Mackinney showed a simple apparatus for demonstrating experimentally the effect of different types of headlights and lens-combinations. This consisted in two small electric glowlamps behind a screen of semi-transparent paper; sockets were arranged in front of each of these two lamps, into which any desired lenses could be inserted. He first threw on the screen the two ordinary projector beams slightly overlapping in the centre. Next, the spherical lenses were replaced by high-power cylindrical ones, as suggested by Dr. Hickman, the axes being horizontal. By this means two beams flattened in a horizontal plane, which again overlapped in the centre, were produced. This general shape was a good one, but he thought the outer parts of the beam were not sufficiently bright in comparison with the central region; it would be better if the illumination could be arranged to shade off more gradually. Mr. Mackinney subsequently showed how, by using crossed cylindrical lenses with *positive* power in the vertical meridian and *negative* power in the horizontal meridian, a beam that was rectangular in section and of uniform brilliancy could be obtained. This idea of introducing a negative component in the lens system seemed to be new, and might possibly be found of practical utility in designing headlights. By a slight modification in the lens system, the intensity of the light could be made to gradually diminish horizontally; by this means the most brilliant illumination was secured in front of the car and a comparatively subdued effect produced on the side-walk, so as not to inconvenience pedestrians by "glare."

* *Proc. Am. Institute of Elec. Engineers*, July, 1910, pp. 1233-1251.

Mr. C. W. S. Crawley said he had hoped to see present some members of the Headlights Commission of the Royal Automobile Club, but unfortunately, although he had tried hard to get some of them to come to the meeting, none were able. He believed that the curious regulation with regard to swivelling headlights was the result of the action of an exceedingly foolish motorist, who mounted a searchlight on his car and started flashing it all over the country, and on some prominent official of the Local Government Board. It was never intended to apply to the ordinary swivelling headlights, and it was perfectly true that the Royal Automobile Club had reported that they did not consider swivelling lamps illegal, although they did not actually guarantee members' prosecution expenses. He did not think that fog was going to act in any way as a luminous source, and the crossing of the beams would not have the smallest effect. As to the real use of headlights motorists would not objeet to a regulation prohibiting them in towns. As regards unduly dazzling lights he he thought that for the present the police might be left to decide what was a nuisance and what was not.

Mr. H. S. Ryland said a point which appeared to have been overlooked was that the ordinary motor car lamp really gave two beams. They either had a reflector behind and plain glass in front, in which case there was one beam produced by the reflector and another by the radiation of the flame; or they had a reflector behind and a lens in front. In this latter case they had one beam produced by the combination of the reflector and the lens, and another by the radiation through the lens alone. Where there were only one or two lights on the car, this was very often what was wanted, because they wanted one beam to illuminate the area just about the car and another to go further ahead. The more nearly a complete sphere they made the mirror the more of the light generated by the source would they get on to the road where it was wanted.

If one wanted a perfectly homogeneous beam, the only way was to adopt the method used in a magic lantern, *i.e.*, one must first of all collect the light by means of a condensing lens, then throw the light well forward, and at the focus put a projecting lens. By that means a beam was obtained which was perfectly homogeneous. He had adopted this method for other purposes, and found it very successful.

He was very pleased to see the author had raised the question of the size of flame with regard to divergence. There were many text-book writers who regarded the whole thing as being a small source of light, and they forgot altogether that when the the flame assumed any dimensions at all the whole of their pretty drawings were spoiled. Another point that might very well be considered was this: When meeting a car there was a brilliant light in front, and the moment the car passed, there was no light at all. If motor cars had lights behind as well as in front—he was speaking from the point of view of the cyclist—it might possibly be a help towards preventing accidents from meeting things behind a car. He once had an accident of that kind whilst riding a bicycle.

Dr. Hickman had showed a type of lamp using prisms at the top of the front glass. As a matter of fact, these did not throw the light down to any considerable extent, and if they were going to use prisms at all, the only logical way was to carry the prisms over the whole surface of the front of the lamp.

When meeting a car, say for instance on the Hampton Court Road, it was very difficult to see whether the lights were at the extreme width of the motor car, and this made the passing of it a matter of some discomfort. On the other hand, a tramcar on this road could be passed with comfort, as there was a space of light all round it. He was of the opinion that a smaller source of light was required, and the attention of metal filament lamp makers might well be drawn to this necessity. He had been told that a

well concentrated metal filament could not be made owing to the jolting which made the wires come together and short circuit the lamp. He should have thought this could be overcome.

Dr. Hickman, in reply to the Chairman's observation that the car in his drawing was on the wrong side of the road, said he did not drive in that way himself, but that the position showed was unfortunately a correct representation of what often occurred. With regard to the definition of "glare," to which Mr. Trotter took exception, perhaps he had not made himself clear as to what he meant; at any rate, he was rather afraid of defining glare after the amount of discussion it had given rise to at previous meetings. Possibly there should be another name for the unpleasant conditions existing when one was trying to see something indifferently illuminated, but in proximity to a brilliant light—when, in other words, an object could not be distinguished owing to the "light in one's eyes" from some other source.

In Fig. 12 it is to be noted that so far from the convex lens producing divergence, as at first sight appears to be the case, the natural divergence is actually halved—from 34·5° to 16·5°—thus doubling the intensity and consequent dazzle.

Dr. Hickman lived in the country, and consequently had not yet the opportunity of putting his opinion with regard to the reflection from fog to the test. The remarks of Mr. Reid, however, seemed to support his views.

The demonstration by Mr. Mackinney reproduced the idea Dr. Hickman had when designing his lamp with the horizontal cylinder in front, but the beam produced by it was elliptical, due to the flame not being equidistant from all parts of the lens: he would have thought a spherocylinder better than crossed cylinders in Mr. Mackinney's modification.

The difference in comfort between passing a well-lighted tram-car and a motor mentioned by Mr. Ryland might be obviated by some device by which a small portion of the light from the headlamps could be reflected back on to the body of the car, sufficiently low down not to annoy the driver. The homogeneous beam he described would be a great advance.

Referring to the hope Mr. Gaster entertained that rules would be drawn up defining when the light from a motor lamp came within the definition of glare, some such test as that used by the R.A.C. to estimate the extent of dazzling effect might be employed, with special attention to the conditions prevailing at "eye-level." The erratic dazzle from the parabolic-bell form of reflector mentioned in the paper was by no means a mere geometrical construction. Dr. Hickman had recently experienced the blinding flash coming from one of these lamps just before passing a car, and though himself driving behind two good acetylene lamps he was quite unable to be sure he was clear of the mudguards of the other car.

Dr. Hickman thanked the meeting for the kind way in which they had listened to the paper and di cussed it; and he was also much obliged to those manufacturers who had demonstrated with their lamps some of the points he had mentioned.

Among the various lamps exhibited may be mentioned the "Radiumlyte" headlamp of Messrs. J. & R. Oldfield, Ltd., in which a special fixing of the lens admits of expansion and contraction, so that it may be mounted very close to the flame, at short focus; the 8-inch multiplex lens with acetylene generator, supplied by Messrs. Rushmore Lamps, Ltd.; several examples of the "Anti-Dazlo" headlamp, manufactured by Messrs. Salsbury Lamps, Ltd. (a section of the lens used in this lamp, by which, it is claimed, the divergence of the beam in an upward direction is prevented, was exhibited in order to show the construction); Messrs. C. A. Vandervell & Co., three sizes of the model "G" headlight, using 32 c.-p. electric lamps The feature claimed for this type is the special diffusion of the beam, the range of the largest type being 500 yards.

Some Notes on the Motor Exhibition at Olympia.

By an Engineering Correspondent.

In the last number of *The Illuminating Engineer* an account was given of the lighting arrangements at the Electrical Exhibition at Olympia. A few comments on the Motor Car Exhibition, which immediately followed it, may therefore be of interest. The general impression seems to be that the exhibition was very successful. A record attendance was secured, and the arrangement of the exhibits and general organization have received high praise.

In this article it is not proposed to enter into the technicalities of the motor engineering nor to comment on the mechanical details of the cars, etc.; these naturally fall outside the scope of *The Illuminating Engineer*.

But there are two special features of the exhibition which invite attention. The first is the illumination of the stands and exhibits. The second includes lighting arrangements for cars, head lamps, etc.—a section of the motor-car industry in which very rapid progress has recently been made.

ARRANGEMENT OF EXHIBITS.

The arrangement of the exhibits presents in several respects a remarkable contrast with the electrical display preceding it. The scheme adopted was a very convenient and simple one. The floor area was devoted entirely to the cars, the gallery solely to accessories. The various stands were arranged on a uniform plan, the same general style being followed throughout—*i.e.*, the cars were grouped below and the illuminated decorative sign was raised high up in such a manner that it could very easily be seen from a distance, but was not obtrusive at close quarters. As a result there were few instances of powerful unscreened lamps located at the level of the eye. The general illumination of the floor was provided, firstly, by the series of arc lamps hung at a considerable height above the floor; and, secondly, by the light from the signs themselves. Many of the exhibitors incorporated in their signs lamps covered by concentrating reflectors, which were very useful for intensifying the local illumination.

THE LUMINOUS SIGNS.

In the design of the luminous signs themselves a certain artistic skill and also a clear perception of the proper principles to be followed in arranging the light was often shown. The methods of applying the principles were sometimes crude and incomplete, unsuitable forms of reflectors being occasionally employed. When a large number of lamps are collected together for display purposes, it is difficult to avoid altogether a tendency to glare; many exhibitors, however, showed a praiseworthy restraint in the use of bright lamps.

It is true that in some cases bare metallic filament lamps were used as a border to the sign, with the result that its illuminated surface was lost in the glare; but it was much more general to utilize small frosted lamps as the basis of the design, and the results of this method were often quite pleasing. In a few cases an otherwise excellent design was marred by introducing a superflous group of unscreened filaments.

A satisfactory feature was the very general use of signs illuminated by concealed lights. It has been frequently pointed out that this method in general lends itself to much more artistic treatment than do masses of lamps. A typical example of an attempt of this kind was the prominent "Bens" sign (The Brompton Motor Co.). Again, in the Rolls Ryce sign, the letters were formed of polished grey metal and illuminated by lamps concealed in reflectors, and the design was

completed by arms, carrying special hexagonal reflectors of original design, the exteriors of which were also finished in grey. These carried high candle-power tungsten lamps, which were completely screened from the eye and threw their light on the cars below. In the Lanchester sign a somewhat similar style, but executed in white, was adopted; the reflectors might, with advantage, have been carried slightly lower, as the lamps could be seen by spectators at some angles, but the general effect was again striking.

Other examples of this system of treatment were afforded by the Wolsey and Napier signs. In the former case letters of polished copper were illuminated, and the effect was again good as regards general appearance; an objection to the use of polished material, however, is that the images of the lamps themselves are apt to be seen reflected in the surface of the letters, thus giving rise to a spotty appearance. In the Napier sign the results might have been improved by a better designed system of illumination. With the arrangement of simple conical shades and lamps round the sign, only comparatively little of the light from the lamps reached the actual illuminated surface, and the lamps could be seen by observers from below.

Good examples of the illuminated bead method were provided in the Daimler, Davies Bros., and other signs.

Transparencies, opal glass devices, and the like, illuminated from behind, were used with success in some cases, but in others the lamps were not properly distributed or sufficiently numerous, and the brightness appeared rather uneven. In some instances a novel and striking, yet restrained, effect was produced by transparency methods. A notable case was the stand of the Motor Supply Co., on which an opal name-plate, an illuminated clock, and a ring of Spookie lanterns were prominent features; and the stall of Motor Schools, Ltd., using similar methods, but employing Holophane reflectors, was also pleasing. The Hotchkiss design in illuminated opal and beaten metal work was somewhat marred by several clear bulb glowlamps being included. In one or two other cases a satisfactory and restful effect was secured, as far as absence of glare is concerned, but the principle was carried to an extreme, the effect being too flat and subdued.

It may be added that the stalls of some of the technical journals—*The Motor*, *The Chauffeur*, etc.—were also carried out in an effective though subdued manner, absence of glare being a good feature. In this respect they presented a favourable contrast with the stalls of technical journals one can recall at some previous exhibitions. The methods employed for lighting some of the show-placards outside were rather crude, the lamps not being effectively screened from the spectators and the illumination uneven.

There was also a class of signs in which frosted lamps were introduced into and formed a successful integral part of the design, notably, for example, the Darracq and Panhard Levassor: the scheme of decoration was here in white and gold, and the obscured lamps seemed in keeping with the general design; they acted as bright objects themselves, and, as they also illuminated the surrounding white surface of the sign, did not appear undesirably bright to the eyes. In some other signs, for example, the Clement Talbot and Delauney Belleville, an elaborate decorative effect was secured by the combination of lamps and metal work, and in the Arrol Johnston sign an effective combination of green and violet-coloured lamps was secured.

SPECIAL APPLICATIONS OF LIGHT.

It was also interesting to note several examples of special applications of light in order to illustrate certain points in the design of the cars, &c. Thus Delage et Cie adopted the method of placing a sheet of mirror beneath the body of the car and illuminating the under side of the machinery with glowlamps. People could thus see all sides of the mechanism from above. The effect, however, would have been better if the lamps had been concealed, so that the spectators could not see their reflections in the mirror. In the model

of the new Darracq engine, which attracted a continual crowd of visitors, light was also employed. A portion of the cylinder was made of semi-transparent material, illuminated from behind by either green or pink light, in order to distinguish between the periods of charge and exhaust.

Perhaps one of the most striking devices was the gigantic figure in the gallery (associated with the Michelin tyres), who smoked a cigar with a luminous red end, and held aloft a goblet, the contents of which were illuminated by a lamp concealed in his fist.

METHODS OF CAR LIGHTING.

We may next turn our attention to the exhibits dealing with car lighting. There has been a remarkable revolution in methods of lighting motor-cars during the last few years. The speed of these vehicles demands much more powerful headlights than would answer for the old slow-moving horse vehicles, and the comparative abundance of mechanical power in the modern motor-car brings the use of electricity within the range of practical convenience. The ease with which a driver can immediately switch off and on any of his lights is a distinct advantage in favour of electricity, and it is usual to arrange the switches controlling them on a convenient little board on which the voltage and current of the generator are also indicated.

An additional convenience, when a properly worked-out system of electric lighting is used, is the possibility of also having the inside of the car electrically illuminated, and a number of ingenious small ceiling lights for this purpose were on view at the exhibition.

Until recently acetylene was the predominant illuminant for headlights. But with the arrival of small voltage reliable metallic filament lamps the position of electricity was rendered much more favourable. There still remained the inconvenience of having to recharge the accumulators at fairly frequent intervals; but this, too, has now been largely overcome by the use of an additional small dynamo run off the engine for the car. This is made to charge the cells during a great part of the journey and in the daytime, so that they retain their charge, and should not become exhausted for quite a long time, provided the car is in constant use.

The chief points of technical interest in the various systems of car lighting now in use are connected with the arrangements for charging the battery and keeping the lights steady.

The electrical arrangement usually adopted is therefore substantially as follows. The various lights receive current from a battery of accumulators while the car is stationary. When the car is in motion, however, the cells will be charged by a small dynamo driven off the petrol engine, and the fact of the lamps being thus across dynamo and battery in parallel serves to steady the voltage. If the speed is above a certain value, the dynamo charges the cells, as well as supplying current to the lamps. [When desirable, the lamps can, of course, be disconnected and the dynamo merely used to charge the battery.] At a lower speed the load will be shared between the cells and battery. At a still lower speed the cells would, unless special provision were made to prevent it, discharge through the dynamo an unduly large current, and would tend to get run down in doing so. To avoid this it is usual to provide some form of automatic cut-out which cuts the dynamo out of circuit when the speed of the car falls below a certain value. In order to avoid over-running the lamps and over-charging the cells, it is also necessary to take special measures (either by specially designing the dynamo or by the use of some outside device) to prevent the voltage of the dynamo rising too much when the car attains its highest rate of speed. In dealing with these difficulties, considerable ingenuity has been shown.

In the LODGE system of car lighting a permanent magnet dynamo giving only about one-tenth horse-power is used. Under these conditions the result of a rising current is that armature-reaction sets in and checks the rate of increase; after a certain point is reached, a practically constant

current is obtained over a wide range of speed. A special automatic device is also provided on the switchboard, which disconnects the dynamo immediately its voltage falls below that of the cells, but connects it again as soon as its voltage rises above that of the battery. The dials of the instrument on the switchboard are automatically lighted up when the switch controlling the battery is on, and the front of the board carries a lighting-up table for the guidance of drivers.

Special care has also been taken in the design of the filament of the electric lamp used. The small dimensions of the filament used in electric lamps is to some extent a drawback, as compared with the more solid and compact acetylene flame, since it tends to produce a spotty illumination; sometimes an image of the filament is formed on the roadway. This is stated to be avoided in the Lodge system by mounting several filaments side by side in such a way as to resemble closely the structure of a flame.

In the C.A.V. system (C. A. Vandervell & Co.) special measures are again taken to secure a constant current with rising speed. This is accomplished mainly by the judicious use of armature-reaction, in conjunction with certain subsidiary poles incorporated in the magnetic system of the dynamo. A special method is also adopted of preventing the battery discharging itself through the dynamo at low speeds. A mechanical device is provided which enables the dynamo to revolve freely irrespective of the speed of the petrol engine as soon as this speed falls below a certain point. Consequently, when the P.D. of the dynamo falls below that of the cells it is merely driven as a motor. When, however, the speed of the petrol engine motor rises again, the armature is gripped and driven as before, and the dynamo again generates current. This ingenious device removes the necessity for an automatic cut-out.

Other specialities of the C.A.V. system include a rotary switch which can assume either of the following positions: (*a*) Charging (lamps off); (*b*) lights on and engine running; (*c*) lights on, engine stopped or free-wheeling; (*d*) off position.

The headlights used are claimed to be designed so as to cover the whole roadway in front with a specially powerful light, and also to throw some light on the hedges. It is claimed that, with the ordinary silver-plated reflector, a watch can be read on a dark night by the aid of the main beam at a distance of 500 ft.

The ROTAX-LEITNER system (a modification of the Leitner system of train lighting) utilizes a special auto-switch for cutting the dynamo out of circuit when the speed falls too low. An ingenious method of controlling the output of the dynamo and obtaining a constant current with a variable speed is adopted. In addition to the ordinary brushes, placed intermediate between the pole-pieces in the usual way, there is a second pair approximately at right angles to them. The field-magnet's circuit is then excited from adjacent pairs of brushes (set at about 90 degrees). As the speed and main current increases, the flux is distorted in the direction of rotation, and the excitation of the field-magnets correspondingly weakened, with the result that the actual current produced ultimately assumes a nearly constant value independent of the speed.

Other accessories of note in this system are the small roof-lights, also run off the dynamo, the Leitner "C" battery, and the special Rotax swivelling headlights, which are considered very serviceable in turning corners, since they enable the driver to see very readily any obstruction slightly to the side.

In the TRIER AND MARTIN system regulation is again effected by means of a subsidiary pair of brushes, so as to intensify the main flux at low speeds and weaken it at high speeds. A cut-out is employed, in which mercury is drawn up at a predetermined speed by the rotation of the armature, in such a way that it makes contact with an insulated connexion. At low speeds it does not reach this level, and the dynamo is therefore out of circuit. Another feature is the use of the "split-cell" battery, which consists virtually

in two duplicate sets of plates in the same liquid. Twin-wiring may also be employed, and it is claimed that this system virtually removes the possibility of difficulties arising from short circuits and broken contacts in the battery and dynamo connexions.

SEABROOK BROS. utilize a somewhat different method of regulation, namely, an adjustable resistance in the field circuit, which is modified proportionally to the increase in speed. The resistance consists in loose material compressed to a greater or less extent by means of an electro-magnet energized by the dynamo. The "SEABROOK - APLCO" dynamo itself is of a very compact cylindrical shape. The booklet devoted to Seabrook specialities also contains an interesting analysis of the qualifications of a good headlight.

As regards other systems of regulation, we may notice that adopted in the OLDFIELD dynamo (E. J. Hardy), in which the current is kept constant by the aid of a special protected resistance maintained by the current at a high temperature. As the voltage rises, the temperature and resistance increase, thus checking the rise in current (apparently in a somewhat similar manner to the resistance used in series with the Nernst filament). A centrifugal device is used to cut out the dynamo at low speeds.

The main feature of the SEEBRIGHT dynamo of the Simms-Magneto Co. is the combination of high-tension magneto dual ignition and lighting generation all in the one machine. Two armatures are used, the upper one acting as a dynamo in the usual way to charge the accumulators, the lower as an ordinary high-tension magneto.

MOTOR CAR HEADLIGHTS.

The second great improvement in this connection has been the more accurate design of the lens-and-mirror system of the headlights. The object has been to utilize as much as possible of the light yielded by the small electric lamp, and to spread it out in such a way as to illuminate the surface of the road a long distance ahead, to light up to some extent the hedges and sides of the road, and to avoid as far as possible dazzling the drivers of approaching vehicles, pedestrians, and cyclists.

The motorist has now a variety of highly improved types to choose from. Specially designed types are shown with the systems mentioned above, and there are also several firms that show forms of lamps for which special qualities are claimed. Thus the RADIUMLYTE (E. J. Hardy) utilizes a mirror of special annealed glass, which is stated to enable acetylene flames to be used in an exceptionally efficient way. The flame can be brought quite exceptionally close to the surface without danger of its being cracked, so that as much as 50 per cent of the light is received and diverted by the mirror. There is also a method of mounting the mirror with a spring, so that it is not distorted by the heat and its curvature is unaltered. The front part of the lamp can be finished in various ways, according to the object of the light, a long silver-coned reflector being sometimes added to disperse the rays over the ground in front of the car. Other specialities include the Taxi-Illuminator, which consists in a simple, handy lamp to light up the dial without any glare being visible to the driver.

Another set of lamp headlights with special reflectors are the DIAMONLYTE, MOONLYTE, and SUNLYTE (W. J. Harvey). The lamps are hermetically sealed, so that no internal cleaning is required, the chief qualities aimed at in the three distinct types mentioned above being brilliancy, anti-dazzling properties, and penetrating power respectively.

An exhibit which attracted much attention was the "DIVA" headlight shown by Messrs. Peto & Radford. In this case a single 16 c.-p. lamp is inserted in a complete sphere, which is polished internally and equipped with a series of lens-windows. The central window sends out a beam straight ahead. The four others surrounding it direct their beams on to suitable inclined mirrors, which also project their beams forward, so that the one lamp produces five distinct beams. Owing to the inclination of the surrounding mirrors, however,

only the central beam is seen at close quarters, thus being arranged with a view to avoiding unnecessary dazzle. By altering the angle mirrors, the angle of these surrounding beams could be adjusted to any desired extent. This firm has also on exhibit their well-known accumulators, and an interesting display of unspillable cells and pocket lamps was to be seen at the Lithanode stall. The Van Raden batteries were likewise on view, and the GOLDENLYTE headlights and CARLITE lamps, the reflectors in the former being plated with gold, with a view to securing good penetrating power and absence of the "spreading effect" so inconvenient to drivers. The V.R. switch is an interesting device for putting on the head, side, and tail lights in any combination. The switch is also arranged to divide the battery, so that the side lights receive only half the full voltage, and yet give enough light while the car is standing still. An economy can thus be made, and the duration of charge of the cells and life of the lamps extended as far as possible. By another position of the switch it is also possible to have the headlamp fully alight and the side lights only on half voltage.

The BLERIOT exhibit included an interesting self-contained headlight generating and consuming its own acetylene. This firm also showed the oxy-petrol searchlight, in which an oxy-petrol flame plays upon, and brings to brilliant incandescence a lozenge composed of rare earths.

Another exhibit which should be mentioned is the Salsbury Dublito Intensifier and the "Anti-Dazlo" lens. The former consists in the utilization of a small lens-mirror in front of the flame, so that the direct rays are completely screened, while the latter consists in a lens built up with a view to confining the light almost entirely below the horizontal, so as to reduce the possibility of glare to drivers and passers-by. This arrangement has previously been described more fully in this journal.*

* *Illum. Eng.*, vol. ii., 1909, p. 496.

Yet another interesting feature in the display in the gallery was the new model lighting equipment using dissolved acetylene of the Acetylene Illuminating Co., Ltd. The advantages and convenience of dissolved acetylene for motor-car lighting are well known. The cylinder can be readily detached to be recharged and replaced by a full one, and it is stated that the standard 20-ft. cylinder can be exchanged at over 700 garages throughout the country. This firm have also issued an illustrated pamphlet on 'The Evolution of Vehicle Lighting.'

The RUSHMERE headlight was shown in a somewhat striking manner, being mounted alone on a cushion in somewhat subdued surroundings, in a recess draped with curtains.

There were many other exhibits on view showing the degree of specialization to which motor-car lighting is now carried, but which space will not permit to be described in detail. Needless to say, there was a very complete collection of the well-known Lucas lamps, including headlights and handlamps of all descriptions. The Willocq-Bottin Motor Lamp Co. showed a patent new compound projector headlight, a feature of which is that the body is absolutely seamless. It is also stated that the optical arrangements secure a very wide beam, so that a signpost can be read at a distance of five yards without it being necessary to direct the lamps specially upon it.

Other forms of lamps and accessories of all kinds were shown by Rippingille's, E. H. Hill & Co., and G. T. Rickes & Co.

The display in fact showed that the design of lamps and lighting appliances for motor-cars has now reached a highly specialized stage, and there can be no doubt that motorists of the present day will be quick to recognize any substantial improvement in this direction.

Short Notes on Illuminating Engineering.

From all Sources.

Illumination of a Ship in Dock by Mercury Vapour Lamps.

THE accompanying illustration shows the application of mercury vapour lamps to the lighting of the hull of a vessel while undergoing repairs in a dry dock. This is an interesting example of the possibility of using lamps of this kind, where a very extended area has to be illuminated, and where the colour of the light is not of much importance. The diffusive qualities possessed by these lamps, due to the large area of the source of light, would also be advantageous. The installation depicted here consists of Quartzlite lamps supplied by the Brush Electrical Engineering Co., to whom we are indebted for the illustration.

Insufficient Lighting of a Dangerous Road.

A MANCHESTER law case is reported in a recent number of *The Journal of Gas Lighting*. A man obtained £250 damages from the Mayor and Corporation as compensation for injuries received in a motor accident which he alleged was due to insufficient lighting of a dangerous section of the roadway.

The accident occurred at a point where a certain street in Manchester adjoined a deep ravine. The plaintiff's car was driven too near the edge, and fell into the gap owing to the lack of fencing or other protection, and to the fact that the mantle in a gas lamp at the edge of the ravine was broken, so that the lamp was giving very little light at the time. Furthermore, the lamps in a street on the opposite side of the ravine were placed so as to appear in a line with those on the near side, thus giving the impression that the roadway itself was continuous. The jury considered that these facts proved negligence on the part of the authorities, and judgment was given for the plaintiff.

Regulations on Illumination.

ON various occasions summaries have been given in these columns of the existing legislation in different countries bearing on illumination. In most cases it is directed that the lighting should be "adequate," without any precise figures being given.

We notice in an article by W. Mankte-low in *The Electrical Review* for October 6th, a refe.ence to a crude but simple standard suggested by the Incorporated Society of Medical Officers of Health. In connection with underground premises, it is recommended that the illumination should be such that "an official copy of the Abstract of the Factory Act may ordinarily be read in all parts of the bakehouse between 11 A.M. and 3 P.M."

This does at least attempt to specify a certain rough standard, but we may hope that the progress made in instruments for measuring illumination will lead to this more accurate and reliable method being presently applied for this purpose.

A "Trouble" Lamp.

SUCH is the American name of a small electric glow lamp specially designed for use in motor-car repairs when trying to find a small bolt, nut, or tool which may have fallen into an awkward position and be difficult of access. According to *Popular Mechanics*, this special lamp has been combined with an electro-magnetic head which will lift any small part after the lamp has rendered it visible. This recalls a device previously described in these pages, in which a workshop lamp was fitted with an electro-magnetic holder in order that it would remain attached to machinery in any position.

A Good Light Needed for School Medical Inspection.

SOME remarks of Dr. T. W. Napier are reported in a recent number of *The Medical Officer*, in which he emphasizes certain requirements which should be borne in mind when arranging accommodation for the medical inspection of children in schools. We notice that special stress is laid on the need for good light, both natural and artificial, and it is also suggested that a space of at least 20 feet ought to be available for eye-testing, this being arranged either in the length of the room or diagonally if necessary.

The Qualifications of an Outdoor Inspector.

SOME remarks on the above subject by R. Halkett of the Leeds Corporation Gas Department appear in a recent issue of *The Journal of Gas Lighting*. The inspector, it is pointed out, comes into contact with men of such widely differing temperaments that tact and a good knowledge of human nature form essential qualifications. The importance of a very thorough knowledge of the subjects to be discussed is, however, not to be overlooked.

It is also suggested that some amount of general knowledge of the principles of illumination, and an acquaintance with the chief features of other illuminants, is always a valuable asset to the gas inspector.

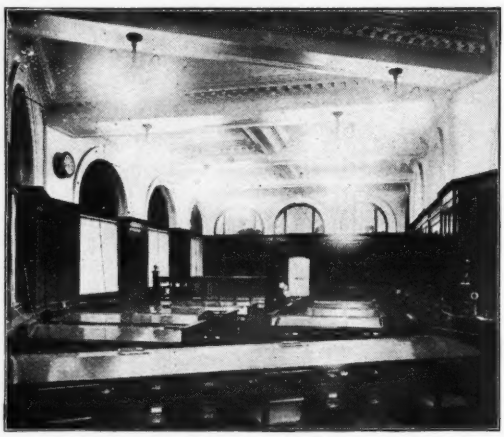
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

An Installation of Mazda Lamps.

We have received from the LIGHTING DEPARTMENT of **Messrs. The British Thomson-Houston Co., Ltd.** (77, Upper Thames Street, E.C.), some interesting particulars of the LIGHTING INSTALLATION at the Royal Insurance Buildings at Aberdeen. The interior of the building has been fitted throughout with Mazda units, *i.e.*, Mazda lamps, combined with suitable Holophane reflectors, specially selected to give any desired distribution. This system of providing the complete lighting unit ensures that the position of the lamp is correct, and that the maximum efficiency is obtained. In the general office of the company, which is a large room, free from supporting columns or other obstructions, a brilliant and uniform illumination has been produced by the use of twelve three-light pendant fittings, equipped with 25 watt Mazda units. The accompanying illustration shows the general effect of the lighting in this office. Similar units have been installed in the secretary's room, while pine-shaped Holophane globes have been used in the halls, corridors, and stairs. A total of 140 Mazda lighting units have been employed throughout the building.



We understand that **Messrs. J. & W. B. Smith** (17–23, Farringdon Road, London, E.C.), whose gas lighting specialities are well known, are now developing an ELECTRIC DEPARTMENT, in which they supply "Siclops" metal filament lamps, and various types of outside lantern fitted for incandescent electric lamps, and suited for shop window lighting and other outdoor purposes.

It is interesting to notice yet another example of a firm previously connected with gas lighting making arrangements to deal with *both* gas and electric fittings, and not exclusively with either.

An Elaborate Advertising Campaign.

Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen Street, Dalston, London, N.E.), have just furnished us with some particulars of their ADVERTISING CAMPAIGN for the present lighting season. The "Little Bill" showcard, which was one of the successful designs in the "Tantalum" Showcard Competition, to which we have previously referred in these columns, has been reproduced in several colours, and many thousands of these have been circulated in practically every town of importance throughout the country. Facsimile reproductions of this poster on post cards can also be obtained for use by contractors in their correspondence. London has been provided for by the usual pictorial advertisements on the Underground Electric Railway systems, and the display of posters on carrier's vans. This poster campaign is intended to keep before the public the claims of "Tantalum" lamps for strength, durability, and efficiency, and we are informed that these arrangements have already resulted in a greatly increased turnover of the lamps.

Junior Institution of Engineers.

VISIT TO THE TOTTENHAM GAS CO.'S WORKS.

A NUMBER of members of this Institution visited the works of the Tottenham and Edmonton Gas Light and Coke Co. on Saturday afternoon, November 18th. Under the guidance of Mr. A. E. Broadberry, the engineer, the party were shown the various retort-houses, the method of charging and discharging in use, and finally the water-gas plant, which was one of the earliest of these plants to be put into operation. At the conclusion the members were entertained to tea, and Mr. Walter T. Dunn took the opportunity of thanking Mr. Broadberry and his staff for making their visit so enjoyable.

ELECTION OF CHAIRMAN.

At the recent Annual General Meeting we understand that Mr. Walter T. Dunn was elected Chairman of the Institution.

Institution of Civil Engineers.

AT the meeting held on November 28th Mr. Roger T. Smith, Electrical Engineer to the Great Western Railway, read a paper on 'Electric Lighting of Railway-Trains: the Brake-Vehicle Method.'

The Association of Engineers-in-Charge.

A MEETING will be held at St. Bride's Institute, Fleet Street, E.C., on Wednesday, December 13th, at 8 P.M., when a paper will be read by Messrs. Geo. Wilkinson and J. Rendell Wilkinson on 'Methods of Dealing with Losses in Steam Plant due to Condensation.'

The Faraday Society.

AN ordinary meeting will be held on Wednesday, December 6th, at 8 P.M., at the Institution of Electrical Engineers, Victoria Embankment, W.C., when several papers will be read, chiefly dealing with 'Thermostats,' of which instruments there will be an exhibit.

Some Publications Received.

The Journal of the Municipal School of Technology, Manchester.—This record of the investigations carried out during 1910 by the members of the teaching staff and the students of the School indicates the large variety of work undertaken. The excellent quality of the printing and illustrations in the report is in itself a testimonial to the photography and printing department of the school, in which, we understand, it was produced.

The Journal of the Franklin Institute.—An account of the International Electrical Congress in Turin by Prof. A. E. Kennelly appears in the November issue.

Sitzungsberichte der mathematisch-physikalischen Klasse der Akademie der Wissenschaften at Munich.—Two volumes for 1911.

We also have to acknowledge the receipt of the following: *The Journal of the Royal Society of Arts, The Transactions of the South African Institute of Electrical Engineers, The Journal of the Royal Sanitary Institute, The Physical Review, The American Chemical Journal, Proceedings of the Tokyo Mathematico-Physical Society, Zeitschrift für wissenschaftliche Photographie Photophysik und Photochemie.*

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

THE majority of articles on illumination during the past month have appeared in the American papers. The *Transactions* of the Illuminating Engineering Society (U.S.A.) for October contain a number of the papers read at the Convention, and the *Illuminating Engineer* (New York) also contains a summary of the proceedings. These papers were dealt with in the last number of this journal.

Several other papers before the American Illuminating Engineering Society have since been read, including a contribution by DR. H. E. IVES, summarizing his **Impressions of Continental Lighting.** Reference is made to the method of suspending flame arcs on long poles, in some cases as much as 50 ft. high. Allusion was also made to the peculiar circumstances in Venice, where street lamps are seen reflected in the water of the canals.

There are also a number of discussions on **Factory Lighting.** Thus in a discussion of a paper by L. P. ALFORD and W. C. F. FARREL on this subject before the American Society of Mech. Engineers, G. H. STICKNEY alluded to the respective functions of general and local lighting, and pointed out that the line dividing these systems was now much less distinct owing to the introduction of such sources as the high candle-power tungsten lamps, standing midway between very powerful arcs and low candle-power incandescent lamps. C. J. MUNDO (*Elec. Rev.*, N.Y., Nov. 4) deals with the illumination of iron and steel works. The first part of the article contains mainly general advice as to avoidance of glare, excessive shadows, &c. The second part contains a useful analysis, in tabular form, of the exact uses to which light is put in the foundry for mould making in machine shops, boiler houses, yards, &c. Cotton Mill Lighting is briefly touched on by J. M. SMITH (*Electrician*, Nov. 17). An interesting statement is that summer-made goods were formerly almost always more expensive than winter-made materials, owing to the fact that the work was done by daylight conditions, and was therefore finer. J. R. CRAVATH (*Elec. World*, Oct. 28) gives an interesting illustration of the value of reflection from the floor of a room in promoting general illumination.

Several recent editorials in *The Journal of Gas Lighting* deserve notice. One of these contains an appreciatory account of the progress of the illuminating engineering movement. Another deals with the suggested scheme for **Street Lighting in the City.** It seems that the project is to light some streets by electricity and others by gas, in both cases the method of central suspension on wires spanning the street being favoured.

In *Electrical Industries* (Nov. 22) J. ECK contributes a popular article pointing out the great practical importance of the study of illumination to the electrical contractor. Stress is also laid on the value of indirect illumination by arc lamps.

ELECTRIC LIGHTING.

Those desiring a comprehensive summary of recent progress in electric lighting will find a very full and readable article by M. SOLOMON in *Science Progress* (July). There are also a variety of contributions on incandescent lamps. G. S. MERRILL (*Elec. World*, Nov. 4) gives some particulars of life tests, and also discusses the spherical reduction factor of different types. A point to be noted is that this factor is materially altered by frosting the lower part of a lamp, and this should be borne in mind in comparing bare and half-frosted lamps. Also the spherical reduction factor may alter considerably during life, and this is not allowed for in life tests made only in a horizontal direction. CH. VALLET (*L'Électricien*, Nov. 11, 18) makes a calculation of the saving in energy, copper, and initial cost of plant by the substitution of metallic for carbon filament lamps.

The Electrical World, N.Y. (Sept. 23), contains some interesting data on **New Types of Small Bulb Lamps** for 100 volts. The introduction of the drawn-wire tungsten filament has rendered possible bulbs of very much smaller dimensions than could formerly be made, and several special spherical and tubular 20 watt types are now available.

An interesting point dealt with in the *Revue Électrique* is the use of **Incandescent Lamps on Low Frequencies,** such as occur in traction. By having two lamps, one with an inductive resistance in circuit, the other with a condenser, a

difference of phase of about 90 degrees, can be produced so that the fluctuations in the light neutralize each other. Several modifications of this method, including the use of two filaments fed in this way, within the same bulb are suggested.

The American journals contain frequent references to the important legal decision requiring the dissolution of the National Electric Lamp Co. It is expected, however, that the beneficial features of the company's work, as regards research and dissemination of information on lamps, will not be materially affected by the decision.

Some interesting suggestions have also been made regarding the use of incandescent lamps in heating and cooking apparatus. The *Electrotechnische Zeitschrift* (Nov. 9) shows some examples of the application of these lamps to heating curling irons, shaving water, &c., special tubular lamps being used when convenient.

Among articles on **Arc Lamps** we may notice the account of the installation at the Turin exhibition of "Conta" arc lamps in series on a 6,300 volt circuit (*Rev. Électrique*, Oct. 13). W. S. Reed (Am. I.E.E. *Trans.*, Nov.) discusses the cost of municipal and private lamp plants for arc lighting. He tabulates the cost per lamp in a number of American cities, and his remarks serve to show how various are the methods of grouping the costs of the different items. It may well be said that it is very difficult to draw any comparison in such cases without going closely into the local circumstances.

G. HILBERT (*E.T.Z.*, Nov. 2) presents some data regarding a three-phase Moore lighting system installed at the Tech. Hochschule lecture theatre at Breslau. A rather peculiar arrangement of the tube, consisting of a loop inside a rectangle, was adopted with a view to securing uniformity of illumination, and the diversity coefficient for the room is given as only 2·45. The three-phase arrangement is beneficial in preventing fluctuations in the light being visible, and the specific consumption is given as 0·442 watts per lux per square metre of floor area.

GAS, OIL, ACETYLENE LIGHTING.

Among the contributions in the British press we may mention the paper read by J. G. CLARK (*J.G.L.*, Oct. 31) on **Some Principles in Governing** in which the efficiency and action of different types of governors for controlling the pressure at consumer's premises are discussed. R. HALKETT (*J.G.L.*, Oct. 24) makes some suggestions as to the **Qualifications of Outdoor Inspectors,** which should include a knowledge of what constitutes good lighting, and of the maintenance of gas lights, and also considerable experience of human nature.

K. LEMPELIUS (*J.f.G.*, Nov. 4) discusses the **Relative Positions of Gas and Electric Lighting** from the gas standpoint. The article also includes a table of the candle-power and efficiency obtainable from the most recent types of high and low pressure gas lamps. E. OTHNER (*J.f.G.*, Nov. 18) devotes himself mainly to the **Hygienic Aspects of Gas Lighting,** discussing the effect of gas on the atmosphere in a room, and contending that the vitiation of the air caused by burners is in general inconsiderable compared with that due to the breathing of people in the room. He also gives tables comparing the intrinsic brilliancy of various illuminants.

Among American contributions we may note that of E. L. ELLIOTT (*Am. Gaslight Jour.*, Nov. 13), who discusses the **Value of Illuminating Engineering** to the gas industry. An interesting item in the paper is a table summarizing the population and activities of the local gas companies in various towns, special reference being made to the attention given to the lighting part of the business, and the education of consumers in good illumination. M. R. MORGAN (*Am. Gaslight Jour.*, Oct. 30, Nov. 6) contributes a serial article in which the **History of Gas Lighting** is dealt with. A list of towns in the United States and Europe, and the date at which gas lighting was introduced in each case, is presented, and some particulars are given of the difficulties experienced by pioneers in this work.

***List of References*:—**

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Ashe, S. W. Training Commercial Men in the Fundamentals of Illumination (*Elec. Rev.*, N.Y., Oct. 28).
Cravath, J. R. Effect of Reflection from Floors (*Elec. World*, Oct. 28).
Illumination for Reading by different Eyes (*Elec. World*, Nov. 11).

Eck, J. Profitable Outlets for Progressive Contractors (*Elec. Industries*, Nov 22).
Editorials. A Concrete Street Lighting Scheme for the City (*J. G. L.*, Nov. 7).
Science of Illumination—Important Movements (*J. G. L.*, Nov. 21).
Workshop Lighting (*Elec. World*, Nov. 14).
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Houston, Prof. R. A. Studies in Light Production (*Electrician*, Oct. 27, Nov. 10).
Ives, H. E. Artificial Illumination in Continental Europe. Paper before the I.E.S. (U.S.A.); (*Elec. World*, Oct. 28; *Elec. Rev.*, N.Y., Oct. 28).
Mundo, C. J. Iron and Steel Works Illumination (*Elec. Rev.*, N.Y., Nov. 4).
Pierce, R.F. The Selection of Factors of Safety for the Designing of Lighting Systems (*Illum. Eng.*, N.Y.).
Smith, J. M. Practical Consideration in Cotton Mill Illumination (*Electrician*, Nov. 17).
Industrial Illumination, as applied to the Iron and Steel Industry. Discussion of the Illum. Eng. Society (U.S.A.); (*Elec. World*, Oct. 28).
The Treasury Department and the Illuminating Engineer (*Elec. World*, Nov. 4).
Lighting of the Hotel La Salle, Chicago (*Illum. Eng.*, N.Y., Nov.).

[*The Transactions of the Illuminating Engineering Society (U.S.A.) for October contains the first instalment of the papers read at the Fifth Annual Convention and dealt with in our last number.*]

ELECTRIC LIGHTING.

Editorial. The Life of Metal Filament Lamps (*Elec. World*, N.Y., Oct. 28).
The Radiation Properties of Incandescent Lamps (*Elec. World*, N.Y., Nov. 4).
Harris, A. W. E. Lighting Efficiency of Metal Filament Lamps (*Engineering*, Oct. 6, 1911).
Hilbert, G. Die Dreiphasen-Moorelichtanlage im Elektrotechnischen Institut der K. Tech. Hochschule, Breslau (*E.T.Z.*, Nov. 2).
Merril, G. S. Candle Power Life Performances of Incandescent Lamps (*Elec. World*, Nov. 4).
Reed, W. S. Cost of Arc Lighting from Municipal and Private Plants (*Trans.* of the American Institution of Elec. Engineers, Nov.).
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Vallet, C. Avantage que presente l'emploi des lampes à Filaments Metalliques (*L'Electricien*. Nov. 11, 18).
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Éclairage à arc sur haute tension (6,300 volts) (*Rev. Electrique*, Oct. 13).
Device for Glowlamps on Low Frequency (*Rev. Electrique*, Oct. 27).
The Cleveland Incandescent Lamp Case (*Elec. World*, N.Y., Oct. 21, 28).
Die Verwendung elektrischer Glühlampen für Heiz und Kochwerke (*E.T.Z.*, Nov. 9).

GAS, OIL, AND ACETYLENE LIGHTING.

Clark, J. G. Some Principles of Governing (*J.G.L.*, Oct. 31).
Elliott, E. L. Illuminating Engineering and its Applications to the Gas Industry (*J.G.L.*, Nov. 14; *Am. Gaslight Jour.*, Nov. 13).
Halkett, R. Remarks on the Outside Department (*J.G.L.*, Oct. 14).
Lempelius, K. Elektricität u. Gas—welche Stellung sollen Sie zu einander einnehmen? (*J.f.G.*, Nov. 4).
Morgan, M. R. The Early Development of Gas Lighting (*Am. Gaslight Journal*, Oct. 30, Nov. 6).
Some Aspects of Lighting (*J.G.L.*, Nov. 21).
Othmer, E. Gas und Hygiene (*J.f.G.*, Nov. 4).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. f. G.—*Journal für Gasbeleuchtung.*
J. G. L.—*Journal of Gaslighting.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

The McGraw-Hill Book Co. (239, West Thirty-Ninth Street, New York) draw our attention to a revised edition of their STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS, in which a very large amount of new matter has been incorporated. Among other special features the number of reference tables on various subjects has been greatly increased.

Mr. Sherard Cowper-Coles informs us that he has now started private laboratories at 1 and 2, Old Pye Street, Westminster, which are being fitted up especially for electro-chemical and metallurgical work. The plant will include an electric furnace, for which a 100 h.-p. transformer is being installed.